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VOL. CXLII.—No. 3696] LONDON: FRIDAY EVENING, NOVEMBER 12, 1926 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director - General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—

1. About 600 Tons MILD STEEL ANGLES, FLATS, ROUNDS and SQUARES.
2. About 180,000ft. of RAILWAY SIGNAL POINT RODDING in 1¼in. M.S. Rod or Plugged Tubing.
3. The SUPPLY and ERECTION on site of new LOCOMOTIVE SHOPS, at Kanchrapara, Eastern Bengal Railway, India.

Tenders due by 2 p.m., 30th November, 1926, for Nos. 1 and 2 ; by NOON, 11th April, 1927, for No. 3. Specifications and forms of Tender obtainable from the above, at a fee of 5s. per set, which will not be returned. 3970

Assistant Engineers (9) REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT for two tours of not less than 12 nor more than 18 months' service in the first instance. Subject to satisfactory service, the officers appointed will be eligible at the expiration of three years' service for confirmation in the permanent and pensionable establishment. Salary, £450, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, preferably between 25 and 30 years of age, unmarried, must have passed the examination for A.M.I.C.E., or possess a degree in Civil Engineering recognised by the Institution as exempting from parts "A" and "B" of the examination. They must have had proper technical training, and preferably have had not less than two years' subsequent experience on large Engineering or Municipal Works. Candidates possessing other Civil Engineering qualifications may apply.—Applications should be made at once by letter, stating age, qualifications, and experience, also whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14485. 3973

Civil Engineer Required for the NIGERIAN RAILWAY (Capital Works) for two tours of 12 to 18 months' service, with possible extension. Salary, £480, rising to £920 a year. Free quarters and passages and liberal leave on full salary. Outfit allowance of £40 on first appointment. Candidates, age 25-35, should have had constructional experience on recognised Railways in the United Kingdom or abroad. Preference will be given to man with a knowledge of trackwork, bridges and culverts. It is desirable they should have passed the examination to qualify for A.M.I.C.E., or hold equivalent qualifications.—Apply at once by letter, stating age, qualifications, and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/14996. 3974

Civil Engineers (5) Required for the PUBLIC WORKS DEPARTMENT of TANGANYIKA TERRITORY for a tour of 20 to 30 months' service, with possible extension. Salary £450, rising by annual increments to £720 a year (with efficiency bar at £600), payable in the Territory in local currency. Outfit allowance of £30 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 25 to 35, preferably unmarried, must have been regularly trained as Civil Engineers and be Corporate Members of the Institution of Civil Engineers. Must be capable of levelling, surveying, measuring up work and preparing designs of bridges, &c. Must have had at least three years' experience under a qualified Civil Engineer on the construction of Harbour Works, Drainage Works, Water Supply, or other Public Works.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/14402. 3952

Brighton Intercepting and OUTFALL SEWERS BOARD.
RECONSTRUCTION OF SEWER OUTFALL AND CONSTRUCTION OF SEA WALL.

TENDERS are INVITED by the above Board for the RECONSTRUCTION of the existing OUTFALL at Portobello, together with SEA WALL and other incidental Works.

The works include the laying of two lines of 60in. diameter Cast Iron Pipes, with an approximate length of 640 yards, and a Sea Wall about 150 yards in length.

Plans may be seen and general conditions, specification, quantities and form of Tender may be obtained at the office of the Engineer to the Board, Mr. David Edwards, M. Inst. C.E., Town Hall, Brighton.

A deposit of Ten Guineas will be required, which will be returned on the receipt of a bona fide Tender.

Sealed Tenders, endorsed "Contract for Sewer Outfall and Sea Wall," to be delivered at the office of the undersigned on or before November 30th, 1926.

The Board does not bind itself to accept the lowest or any Tender.

(Signed) JAS. H. ROTHWELL,
Clerk to the Board.

Town Hall, Brighton. 3940

City of Hull.
TO ROLLER BUILDERS AND OTHERS.

The Corporation is prepared to receive TENDERS for the SUPPLY of a STEAM or INTERNAL COMBUSTION ROLLER having a loaded weight of about 14 tons.

Tenders, accompanied by a full description, including the distribution of weight, endorsed "Tender for Roller," should be addressed to the Chairman of the Works Committee, and delivered at the Town Clerk's Office, Hull, before Noon on Wednesday, the 24th November, 1926.

No special form of Tender is required.

The Corporation does not bind itself to accept the lowest or any Tender.

F. W. BRICKNELL,
City Engineer.

Guildhall, Hull,
5th November, 1926. 3931

Metropolitan Borough of HAMMERSMITH.
ELECTRICITY DEPARTMENT.

The Borough Council invites TENDERS for the SUPPLY of TWO WATER-TUBE BOILERS, each capable of supplying 45,000 lb. of steam per hour, fitted with Mechanical Stokers, Feed Pumps, Fans, Piping, Conveyors, Bunkers, &c.

Specifications, forms of Tender, and other particulars may be obtained from Mr. F. Hill, Engineer and Manager, Electricity Works, 85, Fulham Palace-road, W. 6.

Sealed Tenders, endorsed "Tender for Boilers," must be delivered to the undersigned at the Town Hall, Hammersmith, W. 6, not later than 11 a.m. on Friday, 26th November, 1926.

The Council does not bind itself to accept the lowest or any Tender.

HUGH ROYLE,
Town Clerk.

Town Hall, Hammersmith, W. 6,
8th November, 1926. 3927

The Engineer

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PUBLIC NOTICES

Metropolitan Asylums Board, OPENING OUT AND REPAIR OF ENGINES AND PADDLE WHEELS OF R.A.S. "ALBERT VICTOR."

The Board invite TENDERS for the OPENING OUT, REPAIR and CLOSING UP of the ENGINES and PADDLE WHEELS of the RIVER AMBULANCE STEAMER "ALBERT VICTOR," now lying at South Wharf, Rotherhithe, S.E. 16.

Specification, conditions of contract and form of Tender may be obtained at the office of the Board, Victoria Embankment, London, E.C. 4.

Tenders, addressed as noted on the form of Tender, must be delivered at the office of the Board not later than 10 a.m. on Wednesday, 1st December, 1926.

G. A. POWELL,
Clerk to the Board.

3938

Metropolitan Water Board.
TENDERS FOR THE MANUFACTURE, DELIVERY AND FIXING OF TWO STEAM-DRIVEN ELECTRIC GENERATORS (ONE 100-KILOWATT AND ONE 50-KILOWATT), SWITCHBOARD, PIPING, &c., AT KEMPTON PARK PUMPING STATION, MIDDLESEX.

The Metropolitan Water Board invite TENDERS for the MANUFACTURE, DELIVERY and FIXING of TWO STEAM-DRIVEN ELECTRIC GENERATORS (one 100-kilowatt and one 50-kilowatt), SWITCHBOARD, PIPING, &c., at Kempton Park Pumping Station, Middlesex.

Forms of Tender, conditions of contract, specification and drawings may be inspected without payment of fee at the offices of the Board, Chief Engineer's Department, Room 171, on and after the 15th November, 1926.

Contractors desirous of tendering may obtain the necessary documents from Mr. Henry E. Stillgoe, M. Inst. C.E., the Chief Engineer, on production of an official receipt for the sum of One Guinea, which must be deposited with the Accountant to the Board at 173, Rosebery-avenue, E.C. 1, and will be returned on receipt of a bona fide Tender, together with the above-named documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4.30 p.m. (Saturdays 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.

Tenders, enclosed in a sealed envelope, addressed to the "Clerk of the Board, Metropolitan Water Board, 173, Rosebery-avenue, E.C. 1," and endorsed "Tender for Electrical Plant, Kempton Park," must be delivered at the offices of the Board not later than 10 a.m. on Monday, 6th December, 1926.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
6th November, 1926. 3946

PUBLIC NOTICES

Fylde Water Board.
AQUEDUCT NO. 5 CONTRACT.
DISPOSAL OF PLANT.

The Fylde Water Board are prepared to receive OFFERS for all or any of the CONTRACTORS' PLANT and MATERIAL lying at their Depot at Longridge, near Preston.

All plant, the main items of which are set out below, is in good condition and running order and open to inspection.

A full list of the plant and material for disposal and permission to view can be obtained from the undersigned.

Offers, marked "Aqueduct No. 5 Plant," should be received by me not later than first post Tuesday, December 7th, 1926.

GEO. F. ATKINSON,
Engineer.

Head Office,
Sefton-street, Blackpool.

2 Austin PETROL-DRIVEN TRENCHING MACHINES, each capable of digging a trench up to 4ft. wide by 8ft. deep.
2 Austin CRANE TYPE TRENCH FILLERS, driven by 30 H.P. Petrol Engine mounted on caterpillars.
3 AIR COMPRESSORS, maker Broom and Wade, Dorman Engines, capacity 200 cu. ft. free air per minute.
2 Johnson TAMPING MACHINES, driven by 2 H.P. Petter Engine.
1 Hamworthy PETROL-DRIVEN WINCH.
2 PETROL-DRIVEN CENTRIFUGAL PUMPS, mounted on road wheels, 4in. suction, 3in. delivery, capacity 250 gallons per minute.
One 2-Ton HAND DERRICK CRANE.
One 40 H.P. "Simplex" PETROL LOCOMOTIVE, 2ft. gauge.
2250 Yards PORTABLE RAILWAY TRACK, 2ft. gauge.
6 SETS POINTS and CROSSINGS.
15,000 Yards F.B. RAILS, chiefly 23/24 lb.
7000 WOOD SLEEPERS, 4ft. long.
PNEUMATIC TOOLS, DIAPHRAGM PUMPS, JACKS, BARROWS, SHOVELS, HUTS, CABINS, TOOL BOXES, CHAIN BLOCKS, SHEAR LEGS, GANTRIES, TIMBER, ROPE BLOCKS, BARS, &c. 3957

Sudan Government Railways REQUIRE the SERVICES of DISTRICT ENGINEERS. Age 26 to 32, single. Candidates should have had practical training on a British railway and possess an A.M.I.C.E. degree or equivalent. Starting rate of pay £E480 to £E540 per annum, according to age and qualifications (£E1 equals £1 0s. 6d.). Progressive and pensionable posts if retained. Strict medical examination. Free first-class passage.—Apply by letter, giving full particulars of education, training and experience, to ADVISORY ENGINEER, Sudan Government London Office, Wellington House, Buckingham-gate, S.W. 1, marking envelope "District Engineer." 3950

PUBLIC NOTICES

South Indian Railway Company, LIMITED.

The Directors are prepared to receive TENDERS for the SUPPLY of :—

1. RAILWAY TICKETS.
2. IRON CHAINS.
3. STEEL BEARING PLATES FOR F.B. RAILS.
4. STEAM TURBINE DRIVEN GENERATING PLANT.

Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Railway Tickets," or as the case may be, must be left with the undersigned not later than Twelve Noon on Friday, the 19th November, 1926, in respect of Specifications Nos. 1 and 2, and the 26th November, 1926, in respect of Specification No. 3, and the 3rd December in respect of Specification No. 4.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specifications Nos. 1 and 4, 2s. 6d. for each copy of Specification No. 2, and £1 for each copy of Specification No. 3.

Copies of the drawings may be obtained at the offices of Messrs. Robert White and Partners, Consulting Engineers to the Company, 3, Victoria-street, Westminster, S.W. 1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W. 1,
9th November, 1926. 3961

Barking Town Urban District COUNCIL.
OFFER FOR ROAD ROLLER.

The Council have FOR DISPOSAL a 10-Ton (nominal weight) STEAM ROLLER, by Ruston, Proctor and Co., Ltd., for which OFFERS are INVITED.

The roller may be inspected upon application to the storekeeper at the Council's Stores, East-street, Barking, on any week-day between the hours of 9 a.m. and 5 p.m. and on Saturdays between the hours of 9 a.m. and 12 noon.

Form of offer and full particulars can be obtained on application to Mr. R. A. Lay, Assoc. M. Inst. C.E., Engineer and Surveyor to the Council, Public Offices, East-street, Barking.

Offers, which should be forwarded in the special envelope provided for the purpose, should reach the undersigned not later than 9 a.m. on Tuesday, the 23rd inst.

The Council do not bind themselves to accept the highest or any offer.

By Order,
H. HARGREAVES,
Clerk to the Council.

Public Offices, Barking,
8th November, 1926. 3941

Madras and Southern Mahratta RAILWAY CO., LTD.
VACANCY FOR OFFICER IN STORES DEPARTMENT.

WANTED, ASSISTANT CONTROLLER of STORES, age 24 to 28 years, unmarried, must have good educational qualifications, combined with commercial training.

Desirable knowledge: Mechanical Engineering, Shipping Law, and Marine Insurance.

SALARY.—Rs. 450 to Rs. 600 per month, according to qualifications, with increases on promotion. Required in India immediately.

TERMS.—Subject to a strict medical examination by the Company's Consulting Physician, a three years' agreement in the first instance, a first-class free passage to India and home again on satisfactory termination of agreement, which is extensible by mutual consent. Employee are required to subscribe one month's pay yearly to the Company's Provident Fund, and to those of over five years' service a bonus equal to their contribution is credited, both bonus and contribution accumulating at compound interest until retirement.

Applications, with copies (NOT ORIGINALS) of testimonials, should be made by letter only and addressed to the undersignes not later than 26th November, 1926. Details must be given in chronological order, with dates, of general and technical education and practical experience, if any. Special forms of application will be sent to candidates who appear to have the necessary qualifications.

By Order,
C. L. MAGNIAC,
Brig.-General,
Secretary.

25, Buckingham Palace-road,
Westminster, S.W. 1.
9th November, 1926. 3958

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PUBLIC NOTICES

Administrative County of LONDON.

A TECHNICAL ASSISTANT is REQUIRED for temporary employment in the Chief Engineer's Department of the London County Council at a rate of pay, according to qualifications, up to £5 a week, exclusive of temporary additions fluctuating in accordance with the cost of living, the present total remuneration on a basic rate of £5 a week being £7 3s. 8d. Candidates must have passed the examination qualifying for Associate Membership of the Institution of Civil Engineers, and preference will be given to candidates with experience in the Design of Steelwork on Bridges and kindred structures, and to those who served or attempted to serve with H.M. Forces. Canvassing disqualifies.

Forms of application can be obtained either personally from, or by sending a stamped addressed envelope to, the Chief Engineer, Old County Hall, Spring-gardens, S.W. 1. The latest date for receiving applications is Friday, 26th November, 1926.

MONTAGU H. COX,
Clerk of the London County Council.
3969

City of Bradford.

ELECTRICITY DEPARTMENT.

DEPUTY CITY ELECTRICAL ENGINEER.

APPLICATIONS are INVITED for the POST of DEPUTY CITY ELECTRICAL ENGINEER to the Bradford Corporation.

The person appointed is required to assist the City Electrical Engineer and Manager in all engineering matters, but principally in connection with the generation and distribution of electrical energy.

Applicants must have received a sound technical education, and have practical knowledge of the design and operation of electrical generating and converting plant and transmission and distributing systems.

The salary attached to the post will be from £750 to £1000 per annum, and candidates are requested, in making application, to state the salary required.

The successful candidate will be required to devote his whole time to the duties of the office, and to reside within the city.

Canvassing members of the Council (either directly or indirectly) will be a disqualification.

Lists of duties and forms on which applications are to be made may be obtained from Mr. Thomas Roles, City Electrical Engineer and Manager, 45 to 53, Sunbridge-road, Bradford.

Applications, endorsed "Deputy City Electrical Engineer," accompanied by COPIES of not more than three testimonials (which will not be returned), to be sent in time to reach me not later than the first post on Tuesday, the 30th November, 1926.

N. L. FLEMING, Town Clerk.

Town Hall, Bradford.
6th November, 1926. 3930

Municipality of George Town,

PENANG, STRAITS SETTLEMENTS.

ASSISTANT ENGINEER.

ADVERTISEMENT.

The Municipal Commissioners of George Town, Penang, REQUIRE an ASSISTANT ENGINEER, aged about 30-32, preferably unmarried, on a three years' agreement, with possible extension.

Applicants must have had a good technical education and regular training as pupil and assistant, preferably in a Municipal or County Engineer's office, and must possess experience in Municipal and General Engineering, including Roads, Buildings, Bridges, Sewerage and Conservancy Work, and the control of workmen.

Candidates must be corporate members of the Institution of Civil Engineers, and preference will be given to those who have passed the Testamur Examination of the Institution of Municipal and County Engineers.

The work of this appointment includes the direction of European engineers and staff and demands organising ability and energy.

Salary, 8400 dollars for the first year, 8700 dollars for the second year, and 9000 dollars for the third year of the agreement, rising thereafter by annual increments of 300 dollars a year to 10,200 dollars per annum.

Salary will be paid monthly in dollars, the currency of the Colony, the value of the dollar being 2s. 4d. sterling. In addition, there is at present a temporary allowance of twenty per cent. on the salary for married men and ten per cent. for unmarried men, but these allowances are subject to revision or cancellation at any time. The pay of the appointment at the above rate for the first year, including the temporary allowances, would be £1174 for a married man and £1078 for a single man. An allowance for the maintenance of a motor car when on duty will be granted. Free passage will be provided, with half-pay during the voyage out. The selected candidate must pass an approved medical examination.

Applications, stating whether married or single, age, birthplace, and giving details of education, training and experience generally, with particular reference to the qualifications mentioned above, and accompanied by copies (not originals) of testimonials, to be lodged with Messrs. PEIRCE and WILLIAMS, MM. Inst. C.E., 64, Victoria-street, London, S.W. 1, Agents for the Commissioners, not later than 17th November, 1926.

Further particulars, if desired, can be obtained from the Agents. 3883

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, a MARINE ENGINEER. Fully experienced in High-powered Turbine-driven Ships, to Take Complete Charge of a large vessel for a 700-mile coastal trip.
Address, 3967, The Engineer Office.
3967 A

WANTED, a Well-educated Young ASSISTANT, with preferably university engineering training and practical experience. Must be a good organiser and capable of obtaining productive results. State age, address, and full particulars.—Address, 3964, The Engineer Office. 3964 A

WANTED, First-class CONSTRUCTIONAL ENGINEER, not less than 30 years of age; must have had thorough business and technical training suitable for executive position.—Address application, containing fullest possible information as to training and present position, to 3944, The Engineer Office.
3944 A

WANTED, TECHNICAL ASSISTANT for Works Manager's Office in important Steel Structural Works. Must be young and keen with previous experience.—Address, stating age, qualifications, experience and salary expected, 3833, The Engineer Office.
3833 A

ASSISTANT ENGINEER REQUIRED by a Firm of Consulting Engineers engaged in Waterworks Construction. Applicant should have requisite experience and not be less than 30 years of age. Knowledge of Reinforced Concrete Construction advantageous. State salary.—Address, 3953, The Engineer Office. 3953 A

CHIEF ENGINEER WANTED.—Manufacturing Firm near London employing over 1000, REQUIRE a CHIEF ENGINEER to control staff of 30-40, and take charge of maintenance of large and varied mechanical and electrical plant. Age not over 50. First-class mechanical and electrical engineering qualifications necessary, but specialised knowledge of particular machinery not essential.—Address, stating age, qualifications, and experience, 3971, The Engineer Office. 3971 A

CHIEF MECHANICAL ENGINEER REQUIRED for English-owned Railway in South America. Must have knowledge of ordinary and Rack Locomotives, also Electric Locomotives and Rolling Stock. Knowledge of Spanish advisable. Good climate. Salary £1200 per annum.—Write, stating age, education, training and experience, with copies (only) of testimonials, to Box J.C., c/o Davies and Co., 95, Bishopsgate, E.C. 2. 3939 A

SITUATIONS OPEN (continued)

ENGINEER ASSISTANT WANTED for a Tea Garden in Northern India. Must be educated at a first-class public school, single, between 21 and 23, and fully qualified mechanical engineer with experience of I.C. Engines and Electricity. Salary Rupees 325 per mensem and first-class passage.—Write, with full particulars to "C.C.," c/o J. W. Vickers and Co., Ltd., 24, Austin Friars, E.C. 2. 3925 A

ESTIMATING.—WANTED by Large Firm of Steel Makers, Forgemasters and General Engineers, COMPETENT MAN to Take Control of Works Estimating Department. Applicants may give in strict confidence details of experience, present occupation, age, and salary expected.—Address, P2467, The Engineer Office. P2467 A

FAN ENGINEER WANTED, Having Thorough experience of the design and application of Fans for all purposes. Send full particulars of experience, stating salary required.—Address, 3951, The Engineer Office. 3951 A

MECHANICAL ENGINEER SEEKS POSITION as ASSISTANT to General Manager or as WORKS MANAGER, having had considerable experience in the building of high-class machine tools and cranes.—Address, P2460, The Engineer Office. P2460 A

REQUIRED, GENERAL MANAGER for a large Electrical Power Company in a British Colony, having both Hydro-electric and Steam Stations, who should be a qualified Electrical Engineer with considerable experience in the Handling of the Commercial Side of big Electrical Supply Undertakings. Applicants must be able to negotiate with Government Departments and, if necessary, with consumers. The first engagement will be for a period of three years. Free residence and first-class passage out and home will be provided. Generous salary will be paid to the right man.—Applications giving full particulars as to age, education, training and subsequent experience and salary required, together with copies of testimonials, which will be treated in strictest confidence, to be sent addressed to 3962, The Engineer Office. 3962 A

WANTED, Capable and Reliable DRAUGHTSMAN, preferably experienced in Macadam Quarry Plant.—Address full particulars, P2459, The Engineer Office. P2459 A

WANTED, Good MECHANICAL DRAUGHTSMAN, experienced in Cement, Crushing and Grinding Machinery; one used to preparing complete Lay-out Schemes and with a knowledge of Structural Steelwork preferred. State particulars of experience, age and salary expected.—Address, 3963, The Engineer Office. 3963 A

CENTRAL HEATING.—DRAUGHTSMAN and ESTIMATOR. State age, experience and salary required, by letter only.—JACKSON, 7, Hobart-place, S.W. 1. P2468 A

DRAUGHTSMAN (SENIOR), Used to Fan Design and Application. State age, experience, when at liberty, and salary required.—Address, 3887, The Engineer Office. 3887 A

FIRST-CLASS CRANE DRAUGHTSMAN REQUIRED; thoroughly experienced in Electric Gantry Cranes. Permanent position for suitable man.—Apply, stating age, experience and salary required, to THOMAS SMITH and SONS (Rodley), Ltd., Rodley, Leeds. 3968 A

FIRST-CLASS DRAUGHTSMAN REQUIRED for temporary work in Kent, experienced in lay-out and details of Heavy Cement Works Plant. State age and salary.—Address, 3959, The Engineer Office. 3959 A

MECHANICAL DRAUGHTSMAN, Experienced, REQUIRED; knowledge of Flour Mill Machinery desirable. State experience, age and salary required.—Address, HENRY SIMON, Ltd., 20, Mount-street, Manchester. 3933 A

LEADING STRUCTURAL DRAUGHTSMAN REQUIRED for temporary work in Kent; must be well up in Ferro-concrete, Steel and Heavy Foundations. State age and salary.—Address, 3960, The Engineer Office. 3960 A

REQUIRED, SEVERAL First-class DRAUGHTSMEN, with thorough knowledge of and experience in Civil Engineering. Capable of designing and detailing Steel and Reinforced Concreting Structures. Only those with good technical qualifications need apply.—Address, stating age, experience, and salary required, 3924, The Engineer Office. 3924 A

WANTED for Large Engineering Works in South London, FOREMAN, capable of Taking Charge of a modern Smiths' Shop. Must have experience of General Smiths' Shop practice, Electric and Acetylene Welding and the use of Electric Butt Welding Machines.

Write, stating age, experience, and wages required, enclosing not fewer than two copies of recent testimonials, to "ENQUIRER," c/o E. Anderson and Co., 14, King William-street, Strand, W.C. 2. 3926 A

REQUIRED by Constructional Engineering Firm, competent FOREMAN; one having technical knowledge and experience in control of men preferred. Permanency for suitable man. Full particulars.—Address, 3945, The Engineer Office. 3945 A

PATTERNMAKERS.—Permanency for Capable Men. District rate.—Apply, P. J. SMITH, 3a, Wynyatt-street, Goswell-road, E.C. 1. 3884 A

SITUATIONS WANTED

AERONAUTICAL ENGINEER, with New Designs, sound commercial project, SEEKS APPOINTMENT; 18 years' experience Designing, Constructing; would organise, develop dept. or works. Now disengaged.—NAVARRO, 21, Berrylands-road, Surbiton. P2462 B

SITUATIONS WANTED (continued)

ENGINEER, A.M.I. Mech. E. 39, with Extensive experience of Installation Work and Works Maintenance, DESIRES CHANGE. Home or abroad. Fluent French.—Address, P2466, The Engineer Office. P2466 B

ENGINEER, Commercial and Technical, Successful Inventor, 30 years' experience, SEEKS MANAGING DIRECTORSHIP or other position. Can invest £500 to £1000 in sound concern and bring profitable business.—Address, P2456, The Engineer Office. P2456 B

ENGINEER (42), Extensive Financial and Commercial experience, free in a few months. Accustomed to negotiate and place important contracts, to handle large technical and general correspondence, to control staff, &c. Could be of special assistance to financial or export firm. Prepared to go abroad, but preferably remain London.—Address, P2443, The Engineer Office. P2443 B

ENGINEER (34), Executive PRODUCTION Position; comprehensive responsible high-class mass manufacturing experience, control planning, tools, equipment, &c. Technical and shop trained, energetic.—Address, P2427, The Engineer Office. P2427 B

ENGINEER (39), Contract Finishing Abroad, Railway and dock construction, exp. manufacture rly. and signal material, constructional, gen. eng. erection, speaks Spanish; held responsible posts.—Address, P2426, The Engineer Office. P2426 B

ENGINEER, with First-class Experience in DESIGN, MANUFACTURE, INSTALLATION and RUNNING of all kinds of POWER PLANT and many years as SALES MANAGER, DESIRES POSITION, home or abroad, as GENERAL, WORKS or SALES MANAGER. Undeniable references. Good organiser. Well known in Midlands. Age 40.
Reply, "F.," c/o Clarke, 54, Earlsdon-avenue, Coventry. P2461 B

GENTLEMAN, 23 Years of Age, Well Educated, engineering degree, six years' practical knowledge marine engineering, single and double-acting oil engines a speciality, designer with initiative, DESIRES responsible POST. Moderate salary to commence if position holds prospects for the future. If necessary, willing to invest small capital.—Address, P2438, The Engineer Office. P2438 B

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For continuation of Small Advertisements see page 3.

A Seven-Day Journal

The Spanish-American Air Conference.

THE refusal of Spain to adhere to the Geneva Air Navigation Conference is now explained by the creation of a Spanish-American Air Navigation Convention, the principle of which was decided upon at a recent meeting between Spanish and South American delegates at Madrid. This convention is the logical consequence of the negotiations that have been in progress for some considerable time between the representatives of the Zeppelin and other German companies and the Spanish Government for the creation of a vast aircraft industry in the Peninsula. The idea is to secure for Spain, and incidentally for Germany, complete control over the future air services between Europe and Central and South America. The new convention aims at giving a practical monopoly to Spain, but although it was signed by the South American States, the details were left to be settled at future conferences, for most of the delegates objected to what was called the "ultra protectionist" policy of the Spanish Government. They were not inclined to grant exclusive privileges which would prevent them from treating with other countries. Nevertheless, the convention will certainly enable Spain to carry through its programme, and it was stated at the Conference that the construction of Zeppelin airships and Transatlantic seaplanes would soon be started upon in Andalusia, while in time Spain would develop its aircraft industry to an extent that would not be surpassed in other countries. The State Council has approved of the contract entered into between the Government and the Spanish-German company, whereby a subsidy of half a million pesetas will be granted for each of the first Transatlantic journeys made by Zeppelins and seaplanes within the next three years.

The Belgian Coal Shortage.

THE shortage of coal in Belgium and the high prices demanded for such as is available are seriously affecting both industrial and domestic consumers. The glass works at Blanc-Misseron have had to close down during the last few days, and last Saturday 125 workmen were suspended from the Naval Shipyard at Boom. The Government is endeavouring to induce the miners to work an extra half hour daily to increase the output of coal, but so far the Trade Unions have confined themselves to considering the matter. Meanwhile an Order in Council has been prepared, permitting the Government to requisition 5 per cent. of the coal produced, for the benefit of the areas which are at present suffering acutely from want of fuel. The same Order also places restrictions upon public lighting. The requisitions of coal will be made in agreement with the Federation of Colliery Companies. Monsieur Jaspar, the Prime Minister, in a speech at Liége on Friday of last week, said that in view of the sufferings of the children of Flanders, he could not believe that the miners would refuse the unanimous and legal demand of the nation, that they should work an extra half hour a day till the present crisis was passed. We may add that no licence for the export of coal to England is granted by the Government, however small the consignment may be.

A Co-partnership Scheme.

AT an extraordinary general meeting of the Brush Electrical Engineering Company, held a few days ago in London, the adoption of a co-partnership scheme was considered. In moving the resolutions, Mr. E. Garcke, the chairman of the company, said that the scheme was approved in principle at the annual meeting held in June, and a provisional Co-partnership Council had immediately been appointed. In accordance with the scheme that had been prepared for general circulation, after providing for depreciation and a dividend at the rate of 10 per cent. for the year on the ordinary shares, it was proposed to distribute the surplus to the three classes of employees and to the shareholders in proportion to the total wages, salaries and dividends paid during the year. The amounts so distributed could at the option of the recipients be invested in ordinary shares of the company at par. The shares of £1 each had a present market value of 26s. or 27s., so that the recipients would receive an additional bonus represented by the premium on the shares. The shares issued to the employees would rank in every respect with the shares now issued. The management of the scheme would be under the control of a Co-partnership Council, which would be representative in character, and would consist of eight members and a chairman. The scheme was deemed to come into operation as from January 1st, 1926, and the surplus profits in respect of the year 1925, amounting to £8751, would be distributed as a bonus in accordance with the scheme as if it had been in force for the year 1925. The provisional Co-partnership Council had decided that that bonus, after deducting the proportion belonging to the shareholders in accordance with the scheme, should be applied in payment of ordinary shares required for distribution to the co-partners who were entitled to a share of the bonus as on December 31st, 1926. Under the scheme, the directors were asking both the shareholders and the employees of the company to move in the direction of producing better social conditions. The resolutions were unanimously adopted.

Experimental Tanks and Shipbuilding.

THE subject chosen by Mr. Maurice E. Denny for his presidential address at the opening meeting of the Glasgow University Engineering Society on Thursday, November 4th, was that of the experimental tank, its uses and limitations, when employed as an aid to shipbuilding and marine engineering progress. The firm of Wm. Denny and Brothers, Ltd., of Dumbarton, has always occupied a prominent position as regards experimental tank work, and the subject is one on which Mr. Maurice Denny is well qualified to speak. After describing the work of an experimental tank as used in a commercial establishment, he outlined the general features of two representative installations. Mr. Denny regards the functions of the experimental tank as three-fold. Tank work, he argues, should accelerate knowledge, by substituting model experiments which are quickly and cheaply performed, for the gradual and hazardous process of full-sized development. Further, it enables new ground to be broken and the possibilities of hitherto untried methods to be indicated. Finally, tank work may be regarded in the light of an insurance policy against failure. It was suggested by Mr. Denny that the main problem which is to-day exercising the minds of tank workers is that of the interaction between the hull of a ship and the propellers. Only by selecting the best compromise on the part of both these factors can better propulsive results be obtained.

Sir Alfred Yarrow and the British Association.

SIR ALFRED YARROW has added to his previous generous actions by presenting a donation of £10,000 to the funds of the British Association for the Advancement of Science. Sir Alfred believes that the present needs of the Association in its work for science should receive precedence over provision for the distant future, and has accordingly made it a condition of his gift that the whole of the sum, both as regards capital and interest, should be expended within a period of twenty years. Sir Charles Parsons, who a few years ago gave a donation of the same amount to the Association, has given expression to a similar desire regarding the period within which the money is to be expended. As a result of these two gifts the Association, it is hoped, will be enabled to afford steady assistance to scientific research in the directions indicated as desirable at the annual meetings.

The Shipyard Agreement.

THE new shipyard conciliation agreement, which provides means whereby labour difficulties may be fully discussed and settled without occasioning a stoppage of work, was signed at a joint conference of the Shipbuilding Employers' Federation and the Federation of Engineering and Shipbuilding Trades, which was held in London on Thursday, November 4th, when Mr. John Barr and Mr. W. Sherwood acted as the joint chairmen. We have already referred to this agreement in a leading article published in our issue of December 25th last, while in a Journal note published in February 19th we recorded the almost unanimous voting of the shipyard trade unions in favour of the agreement. It is pointed out by the Federation of Engineering and Shipbuilding Trades that there is now a complete procedure for dealing with disputes in any yard in which they arise, either by district or nationally, with a provision for mutual reference to arbitration. National conferences will meet on fixed dates to deal with the matters referred to them, and failing a settlement at such a conference, a general conference may be called, at which every shipyard union will have the right to attend, and which for the first time in the history of any large industry will be presided over by an independent chairman. This provision is one which, according to the union representatives, should compel the increased confidence of members in the agreement which has now been signed.

Broadcasting.

DURING the course of his recent address before the Wireless Section of the Institution of Electrical Engineers, the new Chairman, Professor C. L. Fortescue, referred to the fact that next year the British Broadcasting Company is to be replaced by a chartered corporation presided over by Lord Clarendon. Whatever view might be held with regard to that change, Professor Fortescue remarked, there were certain outstanding points on which there was universal agreement. In the first place, it was undeniable that the British Broadcasting Company had rendered a great public service and had established traditions which could not lightly be cast aside. Secondly, all agreed that the new controlling body must have sufficient standing to conduct international negotiations on broadcasting matters, and in order that it should have that standing it was essential that it should have some direct relation with the Government. It was generally felt that the status given to the body should enable it to hold its own with other interests likely to clash with those of broadcasting. When two years ago there was a demand from broadcast listeners for a restriction of wireless on ships, most of those who had grown up with the earlier stages of wireless looked upon the demand as ridiculous. Views had, however, changed, and the fact that one person electing to send an unimportant message from a ship in the English Channel could seriously interfere with the pleasure of hundreds of other people and possibly prevent an important Government pronouncement from being received, had led to the conclusion that steps must be taken internationally to reduce interference between the commercial broadcasting services to something much below that experienced round some parts of the coast. It was purely a financial question, and the only fair solution to the difficulty might be that some of the income from the broadcasting licences should be devoted to the improvement of ship's wireless installations.

America's Merchant Fleet.

IT will be recalled that the United States Shipping Board recently invited tenders for the sale or charter of five passenger liners and four passenger and cargo ships which are now being operated by the United States Lines and other American shipowning companies. The offers, six in number, were opened on Monday, November 8th. It is understood that the International Mercantile Marine Company is prepared to pay 4,000,000 dollars for the liner Leviathan and to continue to work it under the flag of the United States, subject to the continuation of existing mail contracts. The Atlantic Transport Company, Ltd., also tendered a similar price for the Leviathan, and, in addition, it expressed its willingness, should the American Government desire it, to operate four of the other ships now run by the United States Lines. For the smaller merchant ships, Winchester and Co. is prepared to offer a price of 200,000 dollars for each of five vessels on the understanding that the firm is authorised to operate the vessels of the United States Lines. It is also understood that the same firm proposes to build two large express liners to be run with the Leviathan, at a total cost of 30,000,000 dollars, the suggestion being put forward that the Shipping Board should grant an advance of two-thirds of this sum under the provisions of the Merchant Marine Act. Among the other tenders were those of the Potter Company and a group associated with Mr. Kermit Roosevelt. The former offered a price of 1,505,000 dollars for either the liner President Harding or President Roosevelt, whilst the latter was prepared to pay 250,000 dollars each for five of the smaller merchant ships.

The Coal Dispute.

THE situation in the coal dispute has developed considerably since our last issue. On Thursday of last week, November 4th, the miners' delegate conference revoked the ill-advised policy, originated in South Wales, which the leaders had been endeavouring unsuccessfully to carry out in the immediately preceding weeks. Faced with an ever-increasing return of the men to the pits, the failure to secure an embargo on the handling of coal and the all but complete failure to secure a financial levy from other unions, the South Wales policy after a month's run was quietly dropped. On Friday, November 5th, the miners' leaders, through the mediation of the Trades Union Congress, met members of the Government and announced that they were willing to agree to district settlements subject to certain safeguarding principles being applied nationally. After the Government had consulted the representatives of the owners, it was found possible to formulate a set of proposals which seemed to stand a reasonable chance of being accepted by both parties. These proposals, to be adopted in all district agreements, specified the minimum district wage, the ratio for the division of surplus profits between the owners and the workmen, the maintenance of the existing method of ascertaining the proceeds of the industry, and a certain minimum for the subsistence wage. The question of hours was not mentioned, for it was understood, at least by the Government and the owners, that that question would have to be discussed separately in each district. The exact phrasing and interpretation of the proposals were debated between the Government and the miners' leaders, and it soon became evident that on the question of hours the Executive had no authority to consent to any departure in any district from the seven-hour day. The discussions were interrupted until the Executive could consult the delegates on the point. The delegate conference assembled on Wednesday, November 10th. At the moment of going to press it would appear that the executive is likely to be given full powers to settle the dispute, and that it is intended to advocate a policy involving the establishment of a national tribunal having authority to review all district settlements.

Entropy and Probability.

By HERBERT BARNES, B.Sc.

No. I.

THE following articles are a free treatment of an article by Dr. R. Plank which appeared in the *Zeitschr. des Vereines Deutscher Ingenieure*, June 19th and July 3rd, 1926. I am indebted to Dr. Plank for his permission to publish them.

Carnot published in 1824 his "Réflexions sur la Puissance motrice du Feu," describing his cycle and reversible engine. Joule in 1843 obtained the first accurate measurement of the dynamical equivalent of a quantity of heat and established the First Law of Thermodynamics on a firm scientific basis. Assuming as an axiom the Principle of the Conservation of Energy, the First Law of Thermodynamics states :—

> "Heat is a form of Energy ; Heat and Work are mutually convertible, a definite amount of Heat being equivalent to a definite amount of Work."

Joule's Equivalent "J" is the number which expresses the ratio of the unit of Heat to the unit of Work. It has the following values, according to the System of Units employed :—

Heat.	Work.	J.
(1) B.Th.U. (the heat required to raise 1 lb. of water 1 deg. Fah.)	Foot-pound ..	778
(2) The (20°) calorie (heat required to raise 1 gramme of water 1 deg. Cent. at a temperature of 20 deg. Cent.)	Joule (= 10^7 ergs) ..	4·180
(3) The kilocalorie (heat required to raise the temperature of 1 kilo. of water from 14·5 deg. to 15·5 deg. Cent.)	k.w.-hour .. Joule ..	1/860 4186

(1) is the measure commonly used in this country ; (2) is the standard unit for scientific work, (3) is the unit recently (1924) legalised in Germany, and it is interesting to note that Germany has at the same time legalised Kelvin's thermo-dynamic scale of temperature, with melting point of ice 0 deg. and boiling point of water 100 deg.

If Q is the quantity of heat measured in units of heat, and W the work measured in units of work, the First Law states, then

$$J\,Q = W \quad . \quad . \quad . \quad . \quad . \quad (1)$$

According to the First Law, we ought to be able to write equation (1)

$$J\,Q \rightleftarrows W \quad . \quad . \quad . \quad . \quad (1A)$$

We know, however, that the transformation $W \rightarrow J\,Q$ is more easily effected than the opposite transformation $J\,Q \rightarrow W$. Only in special circumstances does this latter transformation occur ; the probability of its occurrence is less than that of $W \rightarrow J\,Q$. The Second Law of Thermodynamics differs fundamentally from most natural laws, such as Boyle's Law and Charles' (or Gay-Lussac's) Law. These latter express definite relations between certain quantities, the pressure and volume of a gas at constant temperature, the volume and temperature of a gas at constant pressure, and so on. In mathematical language, they express *scalar* relationships, whilst the Second Law of Thermodynamics is of a *vectorial* character, so to speak ; it expresses a unique direction. $W \rightarrow J\,Q$ occurs naturally ; $J\,Q \rightarrow W$ does not occur naturally, or rather the probability of its occurrence in nature is much more remote. Another way of looking at the matter is to consider that most processes of nature are *reversible* processes, and most natural laws deal with such reversible processes, whilst, almost as a unique exception, the Second Law of Thermodynamics has to do with an *irreversible* process. Clausius, in 1850, enunciated this Law as follows :—

> "Heat cannot *of itself* pass from a body at a lower temperature to a body at a higher temperature" ;

or

> "It is impossible to convey heat from one body to another at a higher temperature by the agency of a purely self-acting machine."

Kelvin stated it as follows :—

> "It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects" ;

and Clerk Maxwell said :—

> "It is impossible, by the unaided action of natural processes, to transform any part of the heat of a body into mechanical work, except by allowing heat to pass from that body into another at a lower temperature."

The principle which all these statements are intended to express represents the teaching of experience, and it was first discovered by Carnot ; though Carnot was wrong in his notions of the nature of heat, which, as we shall see, violate the First Law of Thermodynamics, he nevertheless fully discovered the Principle of the Second Law.

Heat may pass from a warm body to a cold body ; this is a natural process. It cannot *of itself* pass from a cold body to a hot body ; this we may call an *unnatural* process. In other words, the transfer of heat from one body to another is an *irreversible* process. The dynamical laws which govern the movements of bodies in space all represent reversible processes in nature ; potential energy may be changed into kinetic energy, or kinetic energy may be equally changed into potential energy. The laws of electromagnetic action also deal in general with reversible processes. In fact, all the dynamical and other laws, where friction does not enter, are expressed mathematically by equations which imply reversibility of the processes. We find, on the other hand, certain phenomena in nature which seem to be governed, not by exact laws like the Law of Gravitation, for instance, but by *laws of probability*, which can only be determined and expressed statistically. Such phenomena are those of radio-active decay, the transfer of heat, the transformation of work into heat, the diffusion of gases, and most chemical reactions. The changes proceed in a definite direction ; for example, the atom of uranium breaks up, heat flows from a warm body to a cold one, work is transformed into heat, diffusion of gases or chemical reactions go forward in a definite direction, according to the initial circumstances. These directions are what we call the *natural* directions. The opposite processes, the building up of a uranium atom, the passage of heat from a colder body to a warmer body, and so forth, are here *unnatural* processes. They will not take place of their own accord, and only take place, if at all, with the concurrence of some other compensatory processes, going forward in the *natural* direction.

Note that Clausius said : "Heat cannot *of itself* pass from a cold body to a hot body," and we have just said above that the so-called unnatural processes which have been mentioned will not take place *of their own accord*. The question arises, What is meant by these phrases "of itself" or "of their own accord" ? For we know that these unnatural processes do occur. In a refrigerator we cause heat to be transferred from a cold body to a body at a higher temperature ; or, to take an example of a chemical reaction, we know that under suitable conditions of temperature carbon monoxide in the presence of oxygen is converted into carbon dioxide. The reaction occurs in the direction of the upper arrow in the chemical equation

$$2\,CO + O_2 \rightleftarrows 2\,CO_2$$

At temperatures of several thousands of degrees, however, the reverse process takes place, as shown by the lower arrow, and CO_2 breaks up into CO and O_2. In this case and in similar cases it is by the application of the Second Law of Thermodynamics that the chemist is able to determine in which direction the reaction will take place. Even the uranium atom must have been formed at some epoch unless it was created as a uranium atom in the beginning of the world, which seems very unlikely. It is possible, though we have no knowledge of this matter, that the same underlying principle, the principle of the Second Law of Thermodynamics, may be involved in the phenomena of radio-active decay. This underlying principle has been enunciated by Clausius. The Second Law of Thermodynamics is not an exact law, such as the Law of Gravitation or the Laws of Motion seem to be. Boltzmann has said that we must consider the Second Law of Thermodynamics as expressing neither a self-evident truth nor yet a proved fact of experience, but rather a principle of probability. Heat is motion of the molecules, and it will be remembered that Maxwell told us that if we had the power to deal with the individual molecules of a substance, to get hold of them and sort them out, then the limitations which nature seems to impose on us with regard to the transformation of heat and work would disappear. The Second Law represents a certain tendency of nature, an inherent probability that changes will take place in a certain direction rather than in the opposite direction. The probability has reference to the mutual actions of molecules, and if we were dealing with very small quantities of matter containing only a moderate number of molecules, then this probability would show itself in the manner we usually associate with probabilities or chances ; we should observe the action taking place more frequently in one direction than the other. In all our work, however, we are dealing with matter in the bulk, and such is the stability which numbers impart to statistics that we then observe the aggregate of these changes to be invariably in the direction of the greater probability, with a uniformity which has all the appearance of springing from a definite physical law.

We have seen that the transfer of heat from lower to higher temperature or the transformation of heat into work, though unnatural processes in the sense stated, may yet be brought about with the help of accompanying actions proceeding in the natural direction. We want, then, to find out what is the nature and what is the least intensity of these accompanying actions which will bring about these desired results. To answer this question, we must first ask ourselves the question, What is the signification of this natural tendency of which we have spoken, of this greater probability that actions shall proceed in a certain direction rather than in the reverse direction, of these so-called irreversible processes ? The results of actions which are irreversible are cumulative ; therefore, certain irrevocable consequences must in the long run ensue from such actions continually in progress. Such a state of affairs implies a continued evolution of the world in a certain direction. Towards what is this evolution ? If we are to be able to state the fact of this evolution scientifically, there must be some thing of which we may say "it continually increases" or "it continually diminishes" ; we must have something to which we can refer numerically or quantitatively. In the classical mechanics, both the conservation of mass and the conservation of energy are postulated ; therefore, it is neither mass nor energy.

How do we proceed if we wish to obtain work from heat ? We must provide ourselves with a *source* of heat at a temperature T and a *condenser* or reservoir of heat at a lower temperature T_0. In addition, we must have a *working substance* which may be, for example, a gas. In Carnot's ideal *reversible engine* we have a cycle of four operations. First, we may suppose the working fluid already at the temperature T and to receive heat from the source, the flow of heat being maintained by having the source at a slightly higher temperature than the fluid, the difference of temperature being insignificant compared with the range of temperature of the engine ; we say the engine receives heat at the temperature T. By infinitesimal reductions of the pressure the fluid is allowed to expand, always at this same temperature T, and so the fluid does mechanical work against this pressure. Secondly, we suppose the fluid cut off from the source of heat and from all possible sources or reservoirs of heat, so that it can neither gain nor lose heat ; at the same time, it is still allowed to expand and do work by successive infinitesimal reductions of the pressure. This work is performed at the expense of the intrinsic heat of the fluid, which consequently drops in temperature. This kind of expansion is called *adiabatic*, and it is allowed to proceed until the temperature of the fluid has dropped to T_0, the temperature of the condenser. The fluid is then put in communication with the condenser, so that it may impart heat to this latter, and at the same time it is compressed by successive small augmentations of pressure up to a certain point—which is determined by the condition which we wish to fulfil in the fourth stage. In this third operation work is done on the fluid and heat is given up by the fluid to the condenser, which for this purpose is assumed at an insignificantly lower temperature than the fluid. This compression, as also the first expansion, is called *isothermal*—at constant temperature. Fourthly, the fluid is again cut off from all sources or reservoirs of heat and compressed *adiabatically* to that point when it shall have reached again its initial state of volume, temperature and pressure. In this stage work is done on the fluid and its intrinsic heat is increased, which is shown by the rise in its temperature. The same cycle of operations may then be renewed and repeated indefinitely. In each cycle a certain quantity of heat Q is taken from the source, and a certain smaller quantity—though Carnot thought it was the same—Q_0 is imparted to the condenser. In each cycle also a certain quantity of work is performed by the engine in the course of the expansion of the fluid, and a certain lesser quantity of work is done on the engine in the course of the compression of the fluid, and the difference between these two quantities is the net work done by the engine in each cycle. If this is called W and we reckon both heat and work in the same kind of units, which we may do, then

$$Q - Q_0 = W \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The efficiency of the engine is $\eta = W/Q$, or

$$\eta = \frac{Q - Q_0}{Q} = \frac{T - T_0}{T} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

We may perhaps be excused from proving the last part of equation (3), since it is the relation which we now use for our most modern *definition of temperature*. It is the basis of Lord Kelvin's thermodynamic scale of temperature. In any case, natural laws cannot be proved ; experience simply teaches us that things are so and so, or that they happen in such and such a manner, and the substance of this particular natural truth first appeared to the mind of Carnot, though he could not express it in this exact way, for we ought to add that T and T_0 in the equation must be reckoned from the absolute zero of temperature, an idea with which Carnot was probably not familiar. At any rate, Carnot discovered the essence of the truth, for he found that the maximum thermal efficiency of any heat engine was a function of $T - T_0$, the difference between the extreme working temperatures. Note that Carnot's cycle is reversible. Referring to the P–V diagram—Fig. 1—in the case considered the successive operations are represented by the lines A B, B C, C D, D A. By reversing the order of the operations, and by expending an amount of mechanical energy equivalent to that which was received in the previous case, we may convey heat from the cold body at temperature T_0 to the hot source at temperature T ; not only that, but more heat is delivered at the higher temperature than is abstracted from the body at the lower temperature. In this reverse case, we have to assume that the cold source of heat is maintained at a temperature the smallest possible amount higher than T_0, so that the heat may flow from the source to the fluid, and also that the temperature of the hot receiver is the slightest amount lower than T, so that the heat shall be induced to flow from the fluid into this receiver. We have,

then, using the same mathematical conventions as before, the identical equation (2), only with all the signs changed to represent this reverse transformation of work into heat by means of Carnot's theoretical engine. Carnot stated that no heat engine working between the same limits of temperature T and T_o could have a higher efficiency than such a reversible engine, and this statement is a true statement of the Second Law of Thermodynamics.

Equation (3) may be written

$$\eta = \frac{d\,W}{d\,Q} = \frac{d\,Q - d\,Q_o}{d\,Q} = \frac{T - T_o}{T} \quad . \quad . \quad . \quad (3A)$$

where $d\,W$ is any small element of work, and $d\,Q$, $d\,Q_o$ small elements of heat. From equation (3A) we obtain immediately the relation

$$\frac{d\,Q}{T} = \frac{d\,Q_o}{T_o} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

from which we see that in any reversible operation, where the final condition of all the substances is the same as the initial condition, the quantity

$$d\,\varphi = \frac{d\,Q}{T} \quad . \quad . \quad . \quad . \quad (5)$$

taken from one part of the system is equal to that given to another part of the system; in all such cases, $d\,\varphi$ for the whole system is nothing. In any other conceivable case—in any engine, for instance, whose efficiency falls short of the theoretically possible maximum, it is easy to see from the equations that $d\,\varphi$ for the whole system must be positive; it can never be negative. This is the criterion which we sought. If we wish to bring about some process which is not natural, such as the transformation of heat into work or the transfer of heat from a cold body to a hot body, we must arrange matters so that $d\,\varphi$ for the whole system is positive. This gives us the minimum amount of accompanying action in the *natural* direction necessary for the carrying out of any of these *unnatural* processes. The quantity

$$\varphi = \int \frac{d\,Q}{T} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Clausius has called the measure of the Entropy ($\equiv$ transformation value), and according to the Second Law of Thermodynamics, the entropy in any isolated system is something which must always grow or at least remain constant; it can never diminish. For equation (2) is always true (even in the limit when W = O, we can still use this equation), and in the case of any reversible operation Q and Q_o are in such ratio that there is no change of entropy in the whole system. In the case of any irreversible operation which we like to imagine, we shall find that φ will always increase. For example, if a heat engine has less than its theoretically highest efficiency, this means that for the same amount of work W there is a greater expenditure of heat, and instead of using an amount of heat Q we use a greater amount $Q + \Delta Q$. We then have instead of equation (2)

$$(Q + \Delta Q) - (Q_o + \Delta Q) = W$$

and for the change of entropy—

$$\Delta\varphi = -\frac{Q + \Delta Q}{T} + \frac{Q_o + \Delta Q}{T_o}$$

$$\Delta\varphi = -\frac{Q}{T} - \frac{\Delta Q}{T} + \frac{Q_o}{T_o} + \frac{\Delta Q}{T_o}$$

and since the first and third terms balance, this gives

$$\Delta\varphi = -\frac{\Delta Q}{T} + \frac{\Delta Q}{T_o}, \text{ which is} > O.$$

In a similar way, taking the example of the refrigerator, any falling off in the efficiency means a smaller amount of heat abstracted from the cold body for the same amount of work, and if we make the calculation we shall find again that the entropy increases. That it increases in the case of any ordinary transfer of heat from a warm body to a colder one is immediately obvious, and so we get, as a mathematical expression of the Second Law of Thermodynamics,

$$\Delta\varphi \geq O \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Clausius stated that the entropy of the universe tends to become a maximum. We may combine both the First and Second Laws of Thermodynamics into one general statement, as follows:—

"All natural physical actions proceed in such a manner that the total energy of the whole system affected remains constant, and the total entropy increases."

$$\Delta\varphi > O \quad . \quad . \quad . \quad . \quad (7A)$$

The Second Law is expressed mathematically, not by an equation, but by an inequality, and in this we see its vectorial character and its difference from other laws of nature. It reflects the one-sided evolution of the world.

Carnot looked upon temperature as heat level, and he considered that in an engine heat performed work by being "let down" from a higher to a lower level in the same way as water drives a mill. It must be admitted that this is a very seductive hypothesis. Many other analogies immediately present themselves to our view: a quantity of electricity performs work in virtue of its potential, an expansible fluid does work in virtue of its pressure, and Carnot's was the universally accepted view of heat until the results of Joule's careful experiments demonstrated it to be untenable. Nothing less than the most irrefutable proofs sufficed to convince Kelvin, among others, of the falsity of Carnot's conception. Yet, though he had been wrong in this hypothesis of the nature of heat, Carnot had grasped the main principle of the Second Law of Thermodynamics almost in its entirety, for he had shown the ratio of the work W to the heat H in a fully efficient engine to be

$$\frac{W}{H} = C\,(T - T_o)$$

where T and T_o were the extreme limits of the working temperatures, and C was a coefficient which depended in some way on the maximum temperature, being high for low temperatures and low for high temperatures. In the early days tables were prepared by Regnault and others giving the values of C (known as Carnot's function) for different values of T, for the use of engineers. It was only necessary for Joule to point out, in 1848, that the proper value of Carnot's function is the reciprocal of the *absolute* temperature T, and Carnot's equation became the equation of the Second Law of Thermodynamics.

We can restore Carnot's picturesque analogy between the heat engine and the water mill if we consider that it is the entropy and not the heat which represents the water, and if we want a physical picture of entropy this is perhaps the best we shall ever obtain. But we cannot press this or any other analogy with entropy very far. For whereas in the water mill the quantity of water which leaves the mill is the same as the quantity which enters, however inefficient the mill may be, it is only in the case of the theoretically perfect heat engine that we can say the quantity of entropy which leaves the engine is the same as the quantity taken in by it. The analogy holds, however, if we consider a water mill of 100 per cent. efficiency and a heat engine with the maximum theoretically possible efficiency. Then we can say—

Water mill $W = M\,(H - H_o)$,

Heat engine $W = \varphi\,(T - T_o)$,

where W is the work in both cases, M the quantity of water used, and $H - H_o$ the fall in the water mill, φ the quantity of entropy used, and $T - T_o$ the fall of temperature in the heat engine. Fig. 1 is the P–V diagram of the Carnot cycle of operations already described. A B and C D are the two isotherms, B C and D A the two adiabatics, and the area A B C D represents the work done by the engine. On the right is the temperature-entropy diagram for the same cycle of operations. The area A B E F represents the whole of the heat taken in by the engine, the area D C E F represents the heat rejected to the condenser, and the area A B C D is the work done by the engine and is equal to the area A B C D in the P–V or ordinary indicator diagram. The length of the line A B or C D represents the entropy used. A B is the entropy taken in, C D is the entropy given up;

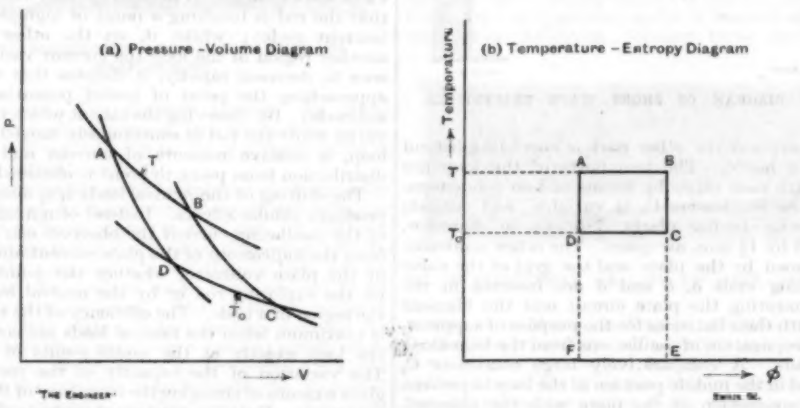


FIG. 1—PRESSURE-VOLUME AND TEMPERATURE-ENTROPY DIAGRAMS

these two balance, and there is neither gain nor loss of entropy in the whole cycle.

$$d\,W = P.d\,V \text{ or } W = \int P.d\,V \quad . \quad . \quad (8)$$

$$d\,Q = T.d\,\varphi, \text{ or } Q = \int T.d\,\varphi \quad . \quad . \quad (9)$$

There is an exact correspondence between equation (8), mechanical energy, and equation (9), thermal energy.

The *state* of a body is a function of two independent variables. P and V (*i.e.*, the reciprocal of the density) define perfectly the physical state of a gas. If Q is the intrinsic heat and T the temperature, these two variables do not similarly define the state of the gas; φ and T do, however, define perfectly the state of the gas. If we wish to define the state of a body in terms of heat alone, that is, we wish to define its thermal condition without any reference to purely mechanical measurements, then we are obliged to introduce this measure φ, the entropy. In the P–V diagram (*a*), any one of the points A, B, C, or D fully defines the state of the working fluid at the particular stage of the operations which it represents; from the P and V the T and the entropy φ may be determined. In the T/φ diagram (*b*) also any point fully defines the state of the fluid, from the T and the φ the P and V may be determined. Areas in both cases represent energy; in the P/V diagram the area A B C D represents the mechanical work performed by the fluid, in the T/φ diagram the area A B C D represents the heat converted into mechanical energy or otherwise dissipated. It is to be noted that equation (9)

$$d\,Q = T.d\,\varphi$$

does not enable us to determine Q from the initial and final states (T′ φ′, T″ φ″) alone, the value of Q depends also on the manner in which the transformation from the initial to the final state has been effected. This is what is meant when, in mathematical works on the subject, it is stated that $d\,Q$ is not a *perfect differential*. The same is, of course, true of $d\,W$ in equation (8); it is not a perfect differential. On the other hand, $d\,Q/T = d\,\varphi$ is a perfect differential, $\int d\,Q/T = \varphi$ being absolutely determined when the initial and final states of the substance are known. 1/T, the reciprocal of the absolute temperature, serves here as an integrating factor.

It has pleased Ostwald to invent two new terms, and to imagine that every manifestation of energy may be represented as the product of an "intensity-factor" and an "extensity-factor." The intensity-factor represents always head, level, or potential. Thus electrical energy is (Voltage) × (Current), the energy of expansion of a gas is measured by the product of the pressure and the change of volume. The conception of entropy permits of the representation of heat energy in an analogous manner. The intensity-factor is temperature and the extensity-factor entropy, as shown by equation (9). Energy in such cases is represented by the area of a curve whose ordinates are these two factors. The energy is given by

$$E = \int y.d\,x,$$

where *y* is the intensity-factor and *x* the extensity-factor. Note, however, that in place of equation (8) for the expansion of a gas

$$W = \int P.d\,V$$

we may write

$$y = P\,V = R\,T,$$

where R is the gas constant, and then $d\,x$ becomes

$$d\,x = \frac{I}{V}.d\,V = d\log V$$

and

$$x = \log V.$$

The equation then becomes

$$W = \int (P\,V).d\log V$$

$$\text{or } W = \int R\,T.d\log V.$$

Here the intensity-factor is proportional to the absolute temperature and the extensity-factor is the natural logarithm of the volume. Areas on a T/log V diagram plotted to a suitable scale represent work done the same as do areas on the P/V diagram. The only advantage of the latter diagram is its greater simplicity. We might in a similar manner obtain other expressions for equation (9) and in place of the T/φ diagram we should have another kind of diagram, less simple perhaps, but otherwise equally as good, in which areas would still represent heat energy, though our two ordinates would no longer be the same. It will be seen, therefore, that the choice of these two factors, of which the product, according to Ostwald, always represents energy, is to a very large extent arbitrary, a matter of convenience, and the fact that the entropy φ very conveniently fills the *rôle* of extensity-factor does not help us very much to form a conception of its physical meaning.

Since the entropy of the world continually grows with the passage of time, some writers have endeavoured to compare entropy with time. But their analogies are too slender and it can hardly be said that their fanciful conceptions tend to clarify our ideas about entropy. In fact the classical mechanics afford no clear analogy. We cannot reach the Second Law

of Thermodynamics by deduction from other more firmly established principles. We must take it *a priori* and the burden of proving it rests on experiment and observation. So long as no known fact contravened it, it was reasonable to accept it as a law of nature like other laws, but now that known facts speak otherwise we are obliged to modify this view and the Second Law loses its position as the expression of a fundamental causal principle of nature. Our ordinary methods of observation dealing with matter in large quantities certainly show results uniformly in accordance with the law as it has been conceived according to the classical mechanics, but many phenomena, and notably those associated with the "Brownian" movements of small particles observed with the aid of the ultra-microscope, lead us inevitably to a different conclusion. Thus during the last twenty years it has come to be recognised that the law is a statistical law merely; it is true in the aggregate when the aggregate is taken sufficiently large, as all statistics tend to steadiness as the number of cases increases. The true character of this law becomes revealed when we apply the statistical methods of analysis; then we may perceive both its scope and its limitations, entropy takes on a real meaning, and a new region of science of surpassing interest unfolds itself before us.

Models and Analogies for Demonstrating Electrical Principles.

No. XIV.*

An investigation of wireless antennae by means of models has been made by Professor J. Tykocinski-Tykociner, who describes a considerable amount of experimental work of this nature in Bulletin No. 147, issued by the University of Illinois. For the most part, the models dealt with are not primarily intended for teaching purposes, but mechanical analogies are used as an introduction to the study of electrical phenomena. A so-called wavemeter bridge has been employed, for instance, to demonstrate and investigate mechanical vibrations of wires which closely resemble electromagnetic oscillations, and which enable one to visualise the relations existing between certain physical quantities involved in the process of sustaining and propagating vibrations.

The bulletin deals, among other things, with the principle of the transmitter for the production of frequencies of from 50 to 100 millions per second. It is very well known that in order to make a three-electrode valve oscillate, it is necessary to choose the conditions of the circuits, so that at any moment the alternating-current potentials of the plate and grid with respect to the filament will be in opposite phase. This condition enables the initial impulse in the oscillating circuit to be amplified and supported by consecutive impulses. In ordinary long-wave oscillating arrangements this is done conveniently by proper connection of the so-called feed-back circuits coupled with the oscillating circuit for the purpose of diverting a fraction of the oscillating energy to the grid circuit. In applying the same scheme to the production of ultra-radio frequencies, however, peculiar properties of circuits become prominent, and must be taken into account. Consider a closed circuit—in the upper part of Fig. 124—with its capacity

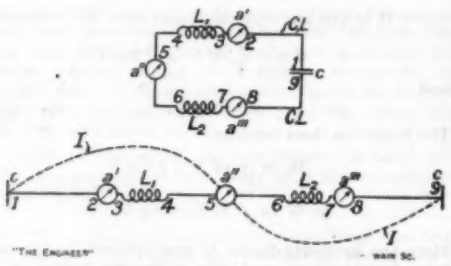


FIG. 124—CURRENT DISTRIBUTION IN HIGH FREQUENCY CIRCUIT

and inductance partly lumped in condenser c and coils L_1 and L_2, and partly distributed along the leads C L. If the frequency is so low that the geometrical length of the circuit is small compared with the wave-length produced, the current will be the same in every section of the circuit. The usual radio frequency circuits have a length l about 50 to 500 times smaller than their wave-length λ. The current distribution along the circuit is therefore uniform and an ammeter a'' inserted at any point of such a quasi-stationary oscillating circuit will show the same current everywhere. But when with increasing frequency the ratio l/λ becomes larger, the uniformity of the current distribution gradually disappears, and, for a frequency sufficiently high, distinct standing waves may build up along the circuit. These waves are illustrated graphically in the lower part of Fig. 124 by a dotted curved line drawn along an identical circuit, but opened in C and extended for the purpose of clearer representation. The current I, measured along such a circuit from point 1 to point 9, shows different values varying from zero at the nodes to maximum values at the antinodes. To avoid complications in the transmitter caused by the use of a combination of circuits in which the current, owing to the very high frequency, cannot be made quasi-stationary, the usual feed-back circuits were discarded altogether. Fig. 125 shows diagrammatically the principle of the arrangement of the transmitter. An oscillating loop is divided symmetrically into two parts. One part, which is used for coupling with a Hertzian oscillator h^1, with an antenna, or with any other circuit to be investigated, is visible outside the

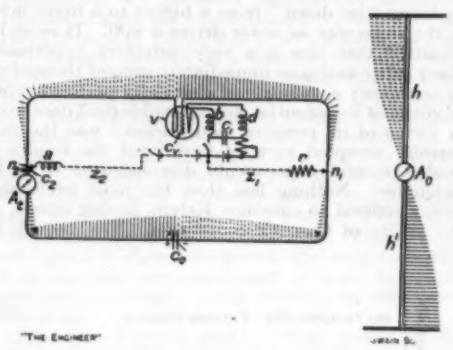


FIG. 125—DIAGRAM OF SHORT WAVE TRANSMITTER

transmitter, and the other part is concealed behind a bakelite board. The two parts of the loop are joined with each other by means of two condensers. One of the condensers C_v is variable, and consists of two semi-circular plates, 7·5 cm. in diameter, separated by 1½ mm. air space. The other condenser C_v is formed by the plate and the grid of the valve V. Choking coils a, b and d are inserted in the leads connecting the plate circuit and the filament circuit with their batteries for the purpose of suppressing the propagation of oscillations from the loop along these leads. A comparatively large condenser C_2 is inserted in the middle position of the loop to prevent a direct connection of the plate with the filament. The thermo-ammeter A_t indicates the maximum effective current in the loop. The zero potential leads z_1 z_2 connecting two symmetrical nodal points n_1 n_2 on the loop contain the grid leak r of about 10,000 ohms resistance on the grid side, and the choking coil a on the plate side. Standard 1-watt and 5-watt valves can be used for obtaining ultra radio-frequency oscillations, but not all of them work equally well. Valves that are too soft do not oscillate at all or are very inefficient. By means of an insulated exploring wire the nodal points n_1 and n_2 can easily be found, and the points where the zero potential leads z_1 and z_2 must be attached are thus determined. The amplitude of oscillation is rapidly decreased by shifting these leads in the direction toward the condenser C_v and C_v. Proper selection of the points for connecting the leads z_1 and z_2 and proper adjustment of the condenser C_v are therefore essential for the efficient production of oscillations. The distribution of potential along the loop is indicated in Fig. 125 by the fine lines drawn perpendicularly to

FIG. 126—TRANSMITTER AND HERTZIAN OSCILLATOR

the heavy line representing the wire of the loop. The length of the lines represents the relative potential difference with respect to the nodal points. Full lines drawn to the right of the vertical parts of the oscillator represent positive values, dotted lines drawn to the left negative values of the potential at the same moment. It is evident from this diagram that the potential at the plate and grid are opposite in phase by nearly 180 deg. Under these operating conditions frequencies of from 50 to 100 millions per second are easily obtained, corresponding to a wave length of 6 m. to 3 m. For longer wave lengths the loop is replaced by rectangular coils.

The complete transmitter is shown in Fig. 126, in which the coupling loop is visible at the left. It can be set in any angular position with respect to an antenna or to any secondary circuit to be excited. To the right of the loop, controlling instruments are mounted on a bakelite board. The terminals of a thermo-ammeter are supplied with two brass tubes, into which a set of rods, tubes and spheres of different dimensions are made to fit, forming Hertzian oscillators. By means of a knob at the back of the transmitter the Hertzian oscillators can be rotated from the horizontal into the vertical position. The fundamental period of the Hertzian oscillators is adjustable by shifting the tubes telescopically.

The following experiments can be easily performed to demonstrate the behaviour of the short-wave transmitter. The most striking phenomenon is the distribution of potential, which is by no means quasi-stationary. A metal rod a few inches in length and supplied with an insulated handle can be used to explore the circuit. The rod concentrates on its surface lines of electric force from the surrounding field, and, like a condenser, is charged whenever approached to or brought in contact with any part of the transmitter loop. When a point of zero potential is touched, the exploring rod takes up no charge, and no influence whatever can be noticed in the operation of the transmitter. If, however, other points of the loop are touched with the rod, four effects are produced:—A certain quantity of energy is translated from the circuit and concentrated around the rod and the effective capacity, and with it the natural period of the circuit, is increased. A redistribution of the current and of the potential along the circuit takes place. The potential at the grid is also affected, and consequently the amplitude of the oscillations must change. All these effects cause, therefore, a variation of the current indicated by the thermo-ammeter inserted in the circuit. When the exploring rod is shifted along the loop, if for certain regions maximum variation of current is noticed, it may be concluded that the rod is touching a point of highest potential (current node); whilst if, on the other hand, in another region of the loop the current variations are seen to decrease rapidly, it denotes that the rod is approaching the point of lowest potential (current antinode). By observing the rate at which the current varies while the rod is continuously moved along the loop, a relative measure of current and potential distribution from point to point is obtained.

The shifting of the neutral leads z_1 z_2 along the loop produces similar effects. Instead of noting variation of the oscillating current the observer can determine from the indications of the plate current ammeter and of the plate voltmeter whether the points touched by the exploring rod or by the neutral leads are in the region of a node. The efficiency of the transmitter is maximum when the neutral leads are connected to the loop exactly at the nodal points of potential. The variation of the capacity of the condenser C_v gives a means of changing the frequency of the oscillating circuit. But this variation of capacity also changes the distribution of current and potential, so that variations of amplitude follow for exactly the same reasons as already mentioned. If the effective capacity of the condenser C_v is much smaller or much larger than the capacity of the oscillating valves, the oscillations cannot be sustained in either case. A remarkable effect of the filament heating current has been observed. The ammeter indications in the oscillating circuit increase rapidly with the increase of filament temperature, but at a certain critical filament current they suddenly fall off, followed by a drop in the plate current and a rise of plate voltage. By using the exploring rod, it can be shown that a sudden radical redistribution of current along the transmitter loop is brought about, with the number of nodes increased whenever the filament heating current exceeds a certain value. This effect is especially marked in the case when the lead z_1 and the grid resistance r are removed. The frequency of the oscillations produced by the method described is constant and depends only on the effective capacity and the inductance of the loop and the apparatus connected with it. Because of this constancy, and of the possibility of measuring the emitted wave length with considerable accuracy, this method of producing oscillations of constant amplitude and frequency can be utilised for a great many investigations in physics and electrical engineering.

The principles of wave measurement are exactly the same as used in ordinary radio telegraphy and Hertzian wave investigations, but the methods have to be changed somewhat in view of the special applications. In radio telegraphy practice a variable condenser of known capacity and a coil of known inductance combined with a hot wire ammeter or thermo-galvanometer constitute all the apparatus necessary for the determination of frequency. The capacity of the coil is in most cases negligible, as compared with the capacity of the condenser; its resistance is also negligible, and the circuit is quasi-stationary, so that Thomson's formula can be applied without correction. In dealing with circuits having a natural frequency that is very high, about 60 millions per second, the current, as already indicated, is not the same in all sections. The distribution of current along the circuit is usually not known, and only for ideal cases can the natural frequency be obtained by calculation. Nevertheless, it is possible to calibrate such circuits by means of stationary waves formed along two parallel wires. Such a system of wires, originally introduced by Lecher, has its capacity and inductance uniformly distributed along the wires, its current distribution is sinusoidal, and the system permits of an absolute measurement of the wave length.

The bridge shown in Fig. 127 consists of two parallel wires, 10 mils (0·025 cm.) in diameter, forming a loop, closed on one side with the thermo-couple of a thermo-galvanometer, and on the other side with a plate set normal to the plane of the loop. When high-

* No. XIII. appeared November 5th.

frequency electromotive forces are induced by the transmitter at one end of the narrow loop, a succession of waves is caused to travel along the wire of the loop. These waves reverse their direction for every alternation of the electromotive force, and each wave on its way back to the origin interferes with those going towards the plate. If the distance between the origin and the plate is exactly equal to half a wave length or to a multiple thereof, the interference of two waves travelling in opposite directions results in a standing wave with current nodes in the middle of the system and with potential nodes at the origin and also at the end plate. By moving the plate along the wires and observing the deflection of a galvanometer, the precise position of nodal points can easily

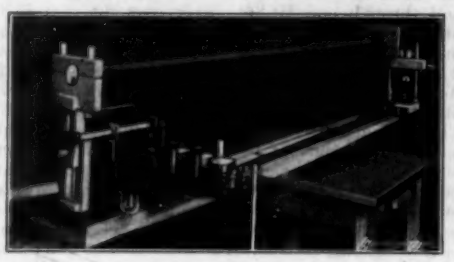


FIG. 127—WAVEMETER BRIDGE FOR ABSOLUTE MEASUREMENT

be determined. The distance between the origin and the first node, or between two consecutive nodes, gives the half wave-length in air of a wave radiated from the transmitting loop.

A calibrating wave meter bridge consists of a wooden frame with two guides running along its entire length and with a pulley mounted at each end. A platform is moved along the guides by a cord running over the pulleys. By means of a screw the platform can be attached to the cord or made loose enough to be shifted directly by hand. The platform carries a horizontal plate with a sliding carriage forming the base of a bakelite support for a vertical screen made of sheet brass. By means of a micrometer screw, the position of the carriage, together with the supported screen plate, can be accurately adjusted. The plate has a horizontal row of fine holes to carry two fine copper wires and to keep them parallel at definite distances from each other. These parallel wires connected at one end by the thermo-galvanometer, after passing at the other end the holes in the screen, are kept under tension by a weight attached to two cords passing over rollers and joined with the wires. By moving the plate along the bridge, the parallel wires of the system become conductively connected with each other at definite distances from their origin. The magnitude of this distance is measured with a meter scale fastened to the bridge, and with a millimeter vernier fixed to the carriage. At the origin of the parallel wire system a clamp attached to a supporting rod carries the short wave transmitter with its coupling loop directed towards the wires. The indicating instrument consists of a Weston thermo-galvanometer in which a group of thermo-couples is connected with a pointer galvanometer. This instrument is mounted in a wooden holder adjustable in a sliding vertical frame, so that the height of the instrument and of the two parallel wires above the transmitting loop can be adjusted, and the coupling with the transmitter thus varied. In order to increase the total length of the parallel wire system, the support for the indicating instrument can be removed from the frame of the bridge and attached to a table at any distance without disconnecting the wires. This is done when measuring wave lengths greater than the double length of the bridge (2.5 m.). As an indication of the accuracy of wave length measurements by this apparatus, it may be stated that, for a frequency of 60 million cycles per second—$\lambda = 5$ m.—when the plate is shifted 2.5 cm. from the point of resonance, corresponding to a discrepancy of 1 per cent. in wave length, the deflection of the thermo-galvanometer is reduced 57 per cent. of its resonance value. A discrepancy of one-tenth of 1 per cent. in wave length is still noticeable. The distribution of the potential and current along the parallel wire system can be studied by the same method as used for the transmitter loop. The system is, however, so sensitive to the slightest displacement of the wires in relation to each other that the method of touching the wires with an exploring handle cannot be used. Instead, aluminium riders with holes in the centre are shifted symmetrically along the wires. With the aluminium disc—1 cm. radius—placed at a distance from the origin corresponding to one-fourth wave length, the deflection of the instrument is reduced 75 per cent., with the disc at a distance of one-eighth wave length 44 per cent., and with the disc at a distance of one-sixteenth wave length 18 per cent.

In view of the increasing importance of electromagnetic waves along wires in connection with carrier wave telephony, short-wave radio communication and electric power transmission, more attention will have to be given in the future to the demonstrating of the properties of these waves and of the laws of their propagation. As an introduction to the study of electrical phenomena, mechanical analogies have proved helpful. The wavemeter bridge has therefore been adapted to demonstrate and to investigate mechanical vibrations of wires which are in close analogy with electromagnetic oscillations. The wavemeter bridge—as shown in Fig. 128—is supplied for this purpose with a mechanical vibrator in place of the electric oscillator. This vibrator consists of a polarised electro-magnet, mounted on an adjustable support. The armature has an extension in form of a rod designed for mechanical coupling with the wires to be set in vibration. In order to regulate the amplitude of motion the armature is damped by means of rubber strips or a spring applied through a lever. A pair of leads connects the electro-magnet with a 110-volt alternating-current source of constant frequency, the actual frequency being 60 cycles per second. The armature, excited by the alternating current, is set into vibration, and on account of its angular (rocking) motion imparts to the stretched wire impulses which, after proper adjustment of the wire length and tension, produce standing waves of a circular type. To visualise the phase relations and the nodes, markers of white thread or white beads are distributed equidistantly along the wire. The antinodes appear to the eye as white circles of maximum diameter, the nodes are visible as brilliant points, while the intermediate marks are seen as circles of smaller diameter. These standing waves can be photographed, and Fig. 128 shows a reproduction of an experiment in which a copper wire, 0.025 cm. in diameter, under a tension of 340 gr., was set in vibration, forming three distinct half

FIG. 128—MECHANICAL ANALOGY OF WAVE PROPAGATION

waves, each 72 cm. in length. In this analogy of mechanical vibrations with electric oscillations, the mass of wire per unit of length corresponds to the inductance of the wire per unit of length, and the tension, or restoring force of the wire, corresponds to the distributed capacity per unit length of the wire. If, therefore, the tension be increased the effect is similar to that produced by increasing the distributed capacity of the wire and consequently when the frequency remains constant the wave length must become longer. In fact, with a tension of 150 grammes the wire shown in Fig. 128 vibrates in four half waves; with 125 grammes tension it vibrates in five half waves; while with 85 grammes tension, six half waves appear over the same total length of the wire. Even as many as fifteen half waves could be produced on the same wire. By varying the length of the wire by means of the fine adjustment screw, the phenomena of mechanical resonance can be demonstrated and studied. In exactly the same manner two wires are set in vibration, each in opposite phase, forming standing waves approaching a complete mechanical analogy with a Lecher parallel wire system.

The Melbourne Sewerage and Sewage Disposal Systems.

In our issues of April 7th and May 5th, 1916, we gave an illustrated description of the various sources from which Melbourne obtains its water supply. Our information was derived from an official publication compiled by Mr. George A. Gibbs, the secretary of the Melbourne and Metropolitan Board of Works, a body which is concerned not only with the water supply, but also with the disposal of the sewage of the district. It was intended that a separate volume dealing with the sewerage system should be published immediately after the book on water supply appeared, but the war caused the project to be temporarily abandoned. Recently, however, the matter was taken up again, and a second volume containing, in addition to the information regarding water supply, a description of the sewerage system of the city and surrounding district, as well as of the method of dealing with the sewage. This second book is also from the pen of Mr. Gibbs, who has courteously furnished us with a copy of it, and from it we have abstracted the following particulars.

Early History.

It is somewhat astonishing to find that, until about the year 1897, Melbourne had no general sewerage system, though the town had been founded as long before that time as 1835, or no less than sixty-two years. The history of the intervening period is interesting. The duty of providing for the sewering of the town devolved upon the City Council under its original constitution in 1842, but, as the Council's powers of borrowing money for carrying out public works and levying rates were limited in the early years of its existence, the establishment of a sewerage system could not be undertaken. "The young town on the banks of the river Yarra was not," we read, "too generously nurtured by its Sydney parent in the period preceding separation of the Colony of Victoria from New South Wales." The bond was severed in 1851, and the condition of the Melbourne municipality thenceforward improved, but the Council's desire to take in hand the public utilities of water supply and sewerage were not supported by the Government of the day. However, a body designated "Commissioners of Sewers and Water Supply" was appointed by the then Colonial Secretary, and it held its first meeting in 1853. Mr. Gibbs remarks that whereas the fact that the word "Sewers" is placed before "Water Supply" in the Commissioners' title would seem to suggest that sewerage was regarded as of first importance, yet it was actually the water supply which received first attention, and it was very many years before anything in the nature of sewerage was undertaken.

Into the reasons for the delay we have not space to go deeply. It appears that, though the matter was continually being brought up for discussion, nothing, from one cause or another, was done. In 1862 the functions of sewers and water supply were transferred to the Department of Public Works, but that body allowed the question of Melbourne to remain in abeyance. The Government would not grant the requisite authorisation for borrowing the money necessary to carry out expensive schemes.

Meanwhile, however, the City Corporation resolutely refused to remain idle, and made strenuous efforts to carry the matter through, though its endeavours met with no immediate success. However, in 1880 the then Mayor offered a prize of £200 for the best essay on the Sewerage of Melbourne, and the successful competitor was Mr. G. Gordon, a civil engineer, who was associated with two other engineers, Messrs. Edwards and Badger. Still nothing was done. Finally, in 1887, a Bill for the creation of a Metropolitan Board was drafted and placed in the hands of the Government, which at last made a move. In 1888 it appointed a Royal Commission to inquire into and report upon the sanitary condition of Melbourne and its suburbs. The Commission's report was completed in 1889.

During that year the Government had arranged for Sir James (then Mr.) Mansergh, M. Inst. C.E., of Westminster, to visit Melbourne, and report upon the sewerage of the town and suburbs. It is of interest to note that, in the course of his inquiries, which resulted in the presentation of a lengthy report, Mr. Mansergh was assisted by Mr. Wm. Thwaites, who afterwards become Engineer-in-Chief to the Melbourne and Metropolitan Board of Works.

The Melbourne and Metropolitan Board of Works.

At the end of the year 1890 an Act was passed constituting the Melbourne and Metropolitan Board of Works, and that body, which assembled for the first time in March, 1891, lost no time in beginning the practical work of sewering Melbourne. The primary object of the creation of the Board was to provide an efficient system of sewerage in the metropolitan area. "The plan recommended by the designer and selected by the Board's Engineer-in-Chief was," says Mr. Gibbs, "estimated to cost £5,030,000, but that plan was modified by the Engineer-in-Chief with the concurrence and assistance of the Board, so as to reduce the estimated cost to £3,451,000. On that estimate detail plans were made, and the work was proceeded with."

The original plan and estimate contemplated only the construction of the main sewers, but Parliament stepped in and ordered the construction of branch sewers and the treating of rights of way as streets and the running of sewers under them. This obligation added considerably to the amount of the original estimate. As a matter of fact, the Board has not only laid branches in the main streets, up to the boundaries of private property, but has also added to the reticulation—in the city of Melbourne proper—every existing lane, passage, alley or court which the owners or occupiers of two or more houses—or of buildings adjoining or abutting thereon—"have the right to use or do use commonly use as a means of access to or drainage from such houses or buildings or properties."

The Sewerage System.

Mr. Gibbs points out that the chief difficulties in dealing with the sewage of Melbourne were:—

(1) The large extent of country over which the population was scattered, only very limited areas having sixty to sixty-five persons per acre, while many of the outlying suburbs had only five to twenty persons per acre;

(2) The extensive areas of comparatively flat country only a little elevated above high-water mark; and

(3) The absence of an outfall within reasonable distance of the city.

The system is described as being "designed to carry off all water used in water-closets, lavatories, baths and urinals, together with all chamber slops and water used in cooking, washing clothes and floors, from sinks in kitchens and sculleries, drainage from stables and cow-houses, also all liquid refuse which in the opinion of the Board will not prejudicially affect the sewers,

the machinery at the pumping station, or the sewage farm at Werribee." Rainfall from the streets, however, flows into the river Yarra, and is not taken into the sewers except under very exceptional circumstances.

The sewers are designed to carry off 30 cubic feet or, say, 187 gallons, of liquid per head per day from an assumed future population of 1,000,000 persons ultimately settled on the original areas capable of being connected to the pumping station. As originally designed, too, every point in the metropolitan area is so governed by the sewers of the scheme that the sewage from any part will, without subsidiary pumping, gravitate to the sumps of one pumping station, which is at Spotswood.

On June 30th, 1925, sewers had been provided for 191,318 houses in twenty-five out of the thirty-eight municipalities then comprising the metropolitan area. In all, there were 484 reticulation areas and over 5000 reticulation extensions in working order at that date. The lengths of 4in., 6in. and 9in. diameter house connection branches and retriculation pipe sewers are connected together and are also further connected with 116 branches, an intercepting sewer, a relieving sewer and a scour main. These branches and sewers are again connected with fourteen sub-mains and mains, and all the services are ultimately connected with two chief mains, viz., the North Yarra main and the Hobson's Bay main respectively. These two chief mains serve as the principal arteries, so to speak, in the two great sewerage systems of the Board—the Northern and the Southern System.

The Northern System comprises a combination of forty branches, one scour main and four sub-mains and mains, all draining into the North Yarra main. This main, which commences as an 18in. diameter pipe sewer and finishes at the pumping station as a 9ft. circular sewer, is 13 miles 3472ft. long—or a total of 72,112ft.—and the cost of it amounted to some £417,090. In carrying out the work several involved problems were met with. A syphon under Stony Creek in No. 1 section, the crossing of the Maribyrnong River in No. 4 section, and the exceptionally bad ground met with in No. 8 section, all introduced special difficulties. Shields were used and 882ft. were carried out under compressed air. In one section 632ft. were constructed under a pressure of 27 lb. to the square inch.

Associated with the Southern System there are no less than seventy-six branches, an intercepting and a relieving sewer, and ten sub-mains and mains, which are all interconnected and discharge the collected sewage into the Hobson's Bay main. This main, which commences as an 18in. diameter pipe sewer and finishes with a diameter of 9ft., is 73,928ft.—just over 14 miles—long, and cost just over £368,100. Great difficulties were encountered in carrying out the work, particularly in crossing under the river Yarra, which operation was effected by means of a shield and compressed air The South Yarra main, which is 31,552ft. long, starts as a 3ft. 6in. by 2ft. 4in. oval sewer, and terminates with its connection with the Hobson's Bay main as a 6ft. 3in. diameter sewer, cost £132,644. The Melbourne main, which starts as a 12in. diameter pipe sewer and terminates at its junction with the Hobson's Bay main, as a 5ft. by 3ft. 4in. oval sewer, is 17,949ft. long.

Lengths and Cost of Sewers.

The total lengths of the various branches and sewers, as well as their combined cost, are set out in the following table :—

	Miles	ch.	ft.	Cost. £
House connection branches—				
4in. pipes	349	67	22	..
6in. ,, ...	42	49	40	
Totals	392	36	62	.. 609,109
Reticulation sewers in rights of way—				
4in. pipes	40	23	3	
6in. ,, ...	231	46	37	
9in. ,, ...	241	46	63	
Totals	513	36	37	.. 1,400,210
Reticulation sewers in streets—				
4in. pipes	4	73	10	
6in. ,, ...	96	12	53	
9in. ,, ...	713	63	2	
Totals	814	68	65	.. 2,979,720
Branches, sub-main and main sewers—				
12in. to 24in. diameter pipes	119	7	40	
3ft. by 2ft. to 6ft. by 4ft. oval sewers	34	59	39	
1ft. 9in. to 9ft. diameter circular sewers ..	25	33	57	
Totals	179	21	4	.. 2,362,313
Grand total				.. £7,351,352

The Pumping Station at Spotswood.

The pumping station is on the banks of the Yarra. It comprises main buildings with north and south engine-rooms and wells, an electrical sub-station, boiler-rooms, coal bunkers, and two large chimney stacks. There are also straining well houses and straining wells, a workshop, store sheds, bath houses and a residence for the Chief Engineer.

The two main sewerage systems, the Northern System—North Yarra main—and the Southern System—Hobson's Bay main—are dealt with in separate buildings, and had originally separate engines and boilers. The two are, however, now arranged to be worked either separately or unitedly as required. The North Yarra main enters the Northern building at a level of 37ft. below low-water mark and 49ft. 6in. below the engine-room floor. The Hobson's Bay main enters the Southern building at a level 45ft. below low water mark and 57ft. 6in. below the engine-room floor. The two sewers are connected in the two engine-rooms, but can be separated by a 9ft. penstock. An auxiliary sewer has been constructed from the Southern to the Northern System, the wells of which were lowered so as to enable four of the Northern engines to pump from the same level as the Southern engines. By this means everything could be combined in duplicate or worked separately as far as the engines and pumps in either building are concerned.

The sewage enters the pumping station through straining wells, one for each system. These wells are 22ft. in internal diameter, and each contains two straining cages, one of which is always in position. The cages may be lifted by winches—operated by air pressure—above the floor of the straining well house, which is 12ft. 6in. above low-water mark.

The engine-rooms are each 113ft. long by 58ft. wide, internally, and the boiler-rooms, which are arranged immediately behind the engine-rooms with the coal bunkers—92ft. 7in. by 26ft.—at their rear, measure 92ft. 7in. long by 50ft. wide. The engine and boiler-rooms and the coal bunkers are spanned by wrought iron trusses with slate roofs boarded underneath. The coal bunkers, which are each capable of holding 950 tons, have a railway siding at the rear connected with the Williamstown Railway at Spotswood Station. The coal is discharged from the trucks directly into the coal bunkers through doors in the back walls. The level of the railway siding is 29ft. 6in. above low water mark, or 17ft. above the boiler-room floor.

In each of the buildings suction wells are provided for six pumping engines, &c., or twelve in all, and enough ground space was left so that the engine and boiler power could be doubled so as to provide an installation of twenty-four engines. The wells are disposed symmetrically on opposite sides of the engine-rooms, and are placed at 33ft. centres transversely and at 34ft. centres longitudinally with the engine-room. At the floor level of the engine-rooms they are elliptical in plan, measuring 27ft. by 15ft., while at the platform 30ft. below low-water mark they become oval, the end of the ellipse being replaced by an arc of a circle of 7ft. 6in. radius, so that at that level they measure 21ft. by 15ft. Each well is independent of the others, and each is separately connected with the central sewer by a 3ft. penstock. All the wells in the Southern building are interconnected at low levels by passage ways.

Prior to October, 1921, only ten engines had been installed—six in the Northern and four in the Southern building. All were triple-expansion condensing engines, and all the pumps were direct-acting plunger machines. Nos. 1, 2, 3 and 4 were of the Worthington pattern, with compensating cylinders, the remainder being of the rotary type. Engines Nos. 1 to 4 were made by Thompson and Co., of Castlemaine ; No. 5 by Hathorn, Davey and Co.; and Nos. 6 to 10 by the Austral Otis Engineering Company, of Melbourne. Each engine has its own condenser and air pump. Steam was furnished by ten internally fired marine return tube boilers, each of about 300 horse-power, made by Thompson and Co., of Castlemaine, the pressure being 150 lb. per square inch. The pumps were collectively capable of lifting 80,000,000 gallons of sewage per day against a head of 125ft.

The Substitution of Electricity for Steam.

In 1921 electric energy was first used to replace steam. At the present time the two systems can be handled wholly by electric energy, or partly by electricity and partly by steam, either separately or unitedly. The normal practice is, however, to do all the pumping by the electrically driven pumps in the Southern building. There the following plant is installed :—(*a*) Two electrically driven centrifugal pumps, each with a nominal capacity of 18,000,000 gallons of sewage daily. These units are operated by 440-volt, three-phase, 25-cycle current obtained from the Railway Commissioners' Newport "A" generating station ; and (*b*) one unit of 18,000,000 gallons capacity and two of 12,000,000 gallons capacity centrifugal pumps operated by three-phase motors, deriving their 50-cycle current at 415 volts from the State Electricity Commission's Yarraville terminal station, which can be supplied from either the Yallourn or Newport "B" generating stations, or from both of them.

Two sub-stations have been erected, one for transforming the 25-cycle and the other for the 50-cycle current. At these sub-stations the current is reduced in pressure from 20,000 volts to 440 and 415 volts respectively. In addition to the electrical pumping units, seven of the ten original steam pumping engines are still in position. The combined pumping capacity of the station is therefore at the present time 134,000,000 gallons per day. The usual practice is to deal with the normal daily load of about 36,000,000 gallons with two 50-cycle and one 25-cycle electric pumps, the remaining two electric units being kept in reserve. For the heavy peak loads, which are sometimes experienced through storm water entering the sewers, either the steam engines or the stand-by electric units are used, according to circumstances.

The Rising Mains.

The pumps in the Southern building lift the sewage from 45ft. below to 64ft. 6in. above low-water mark, or a total litt of 109ft. 6in. from invert to invert. Some of the pumps in the Northern building lift the sewage through a similar height, and others from 37ft. below to 64ft. above low-water mark, or a height of 101ft. 6in. The sewage, relieved of the bulk of the heavy solids, is raised to the head of the outfall sewer at Brooklyn, and the total equivalent head, including friction, is taken to be from 120ft. to 125ft. It is forced through two 6ft. diameter rising mains—one of mild steel and the other of wrought iron—and through one 4ft. diameter wrought iron rising main with 3¾ chains of 6ft. diameter concrete rising main at the top end. The three mains are each 2 miles 63¼ chains long, and they run side by side. Actually, only two of the mains are ordinarily in use at the same time, the third being kept as a stand-by. There are also two 6ft. diameter by-pass rising mains, with a total length of 14 chains 3ft., laid to the north and south outside the pumping station, which have been provided so that the flow can be by-passed outside the buildings, so as to allow of cleansing or repairing the mains and valves within the confines of the pumping station. The total cost of the pumping station and engines up to June 30th, 1925, had been £282,718.

The Outfall Sewer.

From Brooklyn the sewage gravitates to the Metropolitan Sewage Farm at Werribee, in a partly open and partly closed channel, having a gradient of 2ft. to the mile. The sewer is open for a distance of 9 miles 12 chains 54ft., and covered for 6 miles 56 chains 51ft. Where open it is semi-circular in form, and where covered it is circular and has a diameter of 11ft. Both portions are partly in concrete and partly in concrete lined with brick. In the length of the outfall sewer there are three aqueducts, over the Werribee River, Skeleton Creek and Kororoit Creek, and the total length of the sewer, including the aqueducts, is 15 miles 78¼ chains. The maximum capacity—limited to half-full conditions—is 12,500 cubic feet per minute, or, say, 112,500,000 gallons per day.

The total cost of the rising mains and outfall sewer up to the end of June, 1925, had been £448,821.

The Sewage Farm.

The purification of the sewage is effected by broad irrigation. The farm is situated about 24 miles south-west of Melbourne, and 4 miles south-west of the township of Werribee. Its present area is rather over 13,602 acres, or about 21¼ square miles. The land was originally treeless, almost stoneless, open plain country, somewhat clayey and poorly grassed. The average annual rainfall taken over the last thirty years or so has been 18·14. The site has for its eastern boundary the Werribee River, and about 6 miles frontage to Port Phillip Bay on the south. The land gradually slopes from north to south, the highest point being about 65ft. above low-water mark. The outfall sewer delivers sewage at 37·25ft. above low-water mark, and to irrigate the portion of the farm above that level necessitates pumping. Until it was required for sewage disposal, the greater proportion of the area was leased to hay and grain growers, but it has now been almost all resumed by the Board, though there is a considerable area yet to be brought under irrigation.

The process generally adopted for preparing the land for sewage disposal is as follows :—Where the contour of the land permits, the area being prepared is divided into rectangular blocks intersected by roads and by shelter belts of trees every half-mile. These blocks are again subdivided into 20-acre paddocks—20 chains by 10 chains. The soil is broken by a Fowler steam ploughing plant, the bottom being subsoiled to a depth of about 2ft. The blocks are then graded into bays or terraces of about half an acre each, with check banks, and commanded by distributing drains to facilitate rapid and even watering, the method being to flood the land in a manner similar to that used in ordinary irrigation. Deep drainage channels are cut and the soil so obtained is thrown up to form embankments to take the main supply carriers along the boundaries of these 20-acre blocks. The main carriers and drains run parallel north and south through the farm, and are at a distance of half a mile apart. The sub-carriers and drains branch east and west every 10 or 20 chains. The available area of a 20-acre block is reduced to about 18 acres by the space occupied by the carriers, drains, roads and plantations.

The prepared blocks are sown with lucerne or pasture grasses and clovers, and in a very few months are ready to be flooded with sewage. The resultant growth is very rapid. The sewage sinks into and through the soil, and is discharged into Port Phillip Bay as, what is described as being "clear innocuous water," by a series of main effluent drains. French Provence lucerne is grown for hay and grazing and the pasture grasses sown are chiefly English rye and prairie grass. In some paddocks the indigenous

barley grass grows luxuriantly, and clovers of various kinds, including strawberry clover, are spreading rapidly in the older pastures. Not much success has, however, been obtained from sowing clover seed on new ground. Considerable areas have also at times been put under maize for grain and fodder. From 300 to 500 acres of lucerne are cut for hay, which is held in reserve and marketed in accordance with seasonal dictates.

By the system of deep draining adopted a clayey soil, which has a tendency to set hard under ordinary conditions, is brought into a suitable state when well grassed to take—except in winter or in very wet weather—a watering of about 3in. of sewage every two or three weeks, which is equivalent to about 7ft. per annum, including the rainfall, which averages about 18in., and at the same time to carry the equivalent of a grown cattle beast to the acre all the year round.

As dairying is not permitted by the Health Authorities, the Board has to rely for its returns chiefly on the breeding and fattening of cattle and sheep and the agistment of horses sent out from Melbourne. Breeding herds of about 3000 cows—Shorthorn, Hereford and Polled Angus breeds—are maintained. Only registered pedigree bulls of each breed are used, the object being to build up good pure-bred herds of each strain, while at the same time producing early-maturing fat cattle for the Melbourne market. Large numbers of store bullocks are also bought and fattened. There is also a breeding flock of about 2000 Romney and Romney Cross ewes which are bred to pure Romney Marsh rams. In addition, some thousands of store sheep are bought and fattened. Sheep, it may be mentioned, are largely used as scavengers along the margins of the drains and carriers and in the plantations and private roads.

Altogether, there are grazed and fattened on the 8084 acres at present irrigated, from 6000 to 8000 head of cattle and from 5000 to 17,000 sheep, while from 500 to 1000 horses are on agistment. On June 30th, 1925, there were depasturing on the farm 6671 cattle, 4947 sheep and 800 horses, equivalent to a grown cattle beast to the acre in winter.

The farm finds employment for about 200 men, including three shifts of watermen distributing the sewage night and day as it comes down, the peak flow being at night. Many of the employees reside on the farm, where the Board has seventy houses, most of them with half an acre attached for gardens. There are three day schools, a church, a mechanics' institute and library, a post office, a store and a park, while facilities for playing numerous games are provided. A nursery is also maintained for raising trees for planting on the property, from 5000 to 10,000 being put out each season as the area brought under irrigation extends. Up to date 242,000 trees have been planted by the Board.

Generally, the revenue from grazing more than covers the expense of sewage purification, apart from interest on capital, while occasionally, in drought years, the profits are sufficient to pay all charges for sewage purification, including interest. Taking the ten-year period ending June 30th, 1925, the average net cost per annum of sewage purification, including interest charges, was 5·42d. per head of persons served. The farm, it is claimed, is one of the least expensive and most efficient sewage purification undertakings in the world.

Total Cost of the Undertaking.

It will be of interest perhaps to set out in tabular form the costs of each item of the scheme as at June 30th, 1925. They are as follows:—

	£
Reticulation	4,989,039
Main and branch sewers	2,362,313
Farm purchase and preparation	695,727
House connections	551,606
Rising mains and outfall sewer	448,821
Pumping station buildings and engines	282,718
Night-soil sites	34,631
Total cost	£9,364,855

Conclusion.

The limit of the dry-weather flow of sewage that the outfall sewer to the farm could cope with, as at present constructed, is that from a population of 1,100,000 persons. Even if the sewer were enlarged, at an estimated expenditure of £130,500, it would only be able to deal with a dry-weather flow from a population of 2,206,434 persons. The Board contemplates providing for the sewage from a population of 1,187,605 persons in 1935, 2,373,186 in 1958, and 3,922,688 in 1975. We understand that the Sewerage Committee of the Board has under consideration a proposal, brought forward by Mr. A. M. Grant, Engineer of Sewerage, for treating the sewage from a large area in the east and south, which, if carried out, will, in conjunction with the Werribee farm, make it possible to deal with a population of nearly 4,000,000 persons.

It is claimed that the Australian Commonwealth liner Jervis Bay established a record during her last voyage to England, by maintaining daily communication by her wireless apparatus with Sydney throughout the whole trip of 11,000 miles.

Electrical Energy in Switzerland.

The following excerpts are taken from a presidential address to the South Wales Branch of the Institution of Mechanical Engineers, delivered on Tuesday, November 9th, by Professor F. Bacon.

Industrialism Devoid of Ugliness.—You may think it sounds dreadful to hear that engineers are busy transforming Switzerland into a vast power station of an ultimate capacity of some 8,000,000 horse-power; but the Alpine sculpture is on too vast a scale to suffer appreciable disfigurement. The fact is that Switzerland, though already a highly industrialised country, is singularly free from man-made ugliness. Even buildings for purely industrial purposes rarely offend the eye.

In reference to the Langerbrugge power station in Belgium, the steam plant of which became a topic of controversy at our last meeting, The Engineer recently remarked:—"Like nearly all continental power stations, it is handsome and dignified architecturally. The effect is not obtained by any attempt to imitate classic styles, but by the construction of a building obviously appropriate to its purposes and worthy of the importance of the machinery it houses. Continental architects and engineers seem to have a taste in such matters that is all too rare in England" (and I suppose we might dare to include South Wales). The applicability of this comment to the hydro-electric power station in Switzerland struck me forcibly.

Studying Appearances.—As Sir Archibald Barr once pointed out:—"The works of the engineer are to be used by some people; they have to be endured by all. Taking the highest view of our calling—and surely we do not hold that ours is in any sense a sordid or selfish vocation—the engineer fails in the fulfilment of his duty in so far as his works are detrimental to the health or destructive to the property of the community, or in so far as they are unnecessarily offensive to any of the senses of those who are compelled to live with them. There has been too great a neglect of such considerations. The medical practitioner is held negligent of his duty if he acts solely in the immediate interests of his patient, and does not take due precaution to guard against the spread of disease or the offence of the community by the exhibition of unsightly forms. We should take as high a view of our responsibilities."

My impression is that this exhortation is largely superfluous in the case of Swiss engineers. The æsthetic side is put last, but it is not lost sight of. This applies to machinery as well as buildings. It was a Swiss designer of steam turbines who remarked to me:—"We strive to attain safety, reliability, efficiency, economy and convenience by scientific design, appropriate materials and first-class workmanship, and having attained these essentials, we are not content until we feel we have also secured a pleasing appearance."

All-pervading Character of Mechanical Engineering.—It was in the summer of 1874 when the Institution of Mechanical Engineers first visited South Wales, that the late Sir Frederic Bramwell, F.R.S., delivered a presidential address in Cardiff which, on account of its keen perception and breadth of view, will probably never be wholly out of date.

After reviewing the material basis of the civilisation of that day, he summed up in the words:—"In short, it is no exaggeration to say that there is no one want, no one comfort, nor even one luxury, that is not either directly or indirectly dependent on the mechanical engineer for its production, or for the bringing of it within our reach."

I often wonder whether there is any justification other than historical accident for speaking of mechanical engineering as a *branch* of engineering. Would not un-mechanical engineering be a contradiction in terms no matter whether we were referring to a masonry dam, a locomotive, or an armature winding? Surely mechanical engineering pervades all engineering as completely as the physicist's conception of ether pervades the universe, and we do not convey the right impression—indeed it would falsify the idea—if we spoke of ether as a *branch* of the universe.

Switzerland of to-day shows us a concrete instance of the ever-persisting, all-pervading nature of mechanical engineering in a country where 1000 kilowatts per annum are at the disposal of every citizen without the burning of a ton of coal and where the steam locomotive, formerly regarded as the culminating gift of the mechanical engineer to humanity, has all but ceased to traverse the railways originally created for its use. I am here tempted to make a further extract from Sir Frederic Bramwell's Cardiff address, now over half a century old, for it is curiously prophetic of the rise of hydro-electric power—that marvellous marriage of the youngest kind of gearing with the oldest type of prime mover.

A True Prophecy.—After an appeal not to waste coal either in the getting or in the burning which it would puzzle next year's president of the new Institution of Fuel Economy Engineers to improve upon, Sir Frederic Bramwell continued:—"Have we not, in consequence of the facility of the application of coal, been tempted to neglect the other sources of power in Nature? Do we sufficiently utilise the waterfall, the tidal wave, and the force of the wind? And, with respect to the employment of these forces, we should remember that we are enabled to utilise water power in a way which to the engineers of the last century was unknown. They availed themselves of the waterfall, indeed it was their chief source of motive power; but they were compelled to place their manufactories close to the falls; we, however, know that it is perfectly possible to transmit—at some cost by loss of power, it is true, but not at a prohibitory cost—power to long distances."

We may be tempted to suspect that Sir Frederick is about to disclose that Faraday's discovery of electro-magnetic induction, already forty-three years old, was beginning to open up the possibility of power transmission by the agency of electricity; but it is not so.

What Sir Frederick Bramwell had in mind when he stated at Cardiff in 1874 "that it was now perfectly possible to transmit power to very long distances" were agencies such as air or water confined in pipes, rocking rods or more particularly swift-running wire ropes. This latter means, known as telo-dynamic transmission, had just been described before the Institution with special reference to the plant erected by Heinrich Moser at Schaffhausen, Switzerland, as long ago as 1864. This was the wonder of the world for many years and was actually kept running until 1900.

Storage of Energy.—To-day the electrical method may be said to have completely solved the problem of the transmission and distribution of power. As regards the storage of power, however, the electrical method of secondary batteries still falls as far short of power supply requirements as the flying ropes of Schaffhausen would fail in the now commonplace feat of transmitting thousands of horse-power hundreds of miles and incidentally hitching up dozens of power stations to millions of consumers.

Switzerland is up against the storage of energy problem in a much more acute way than any other country in the world. Wherever power is derived from the combustion of fuel man can regulate the combustion more or less to suit the demand for power. But Switzerland wants to live entirely on her native power from falling water. Nature decides when this shall occur and her moods bear no relation to the habits of man. The Rhine refuses to flow full bore from 8 a.m. till noon and then knock off for lunch. The glaciers refuse to melt in the winter, which is the season of heaviest demand for light and heating. The hour to hour variations of load throughout the day and the discordant month-to-month variations throughout the year of both supply and demand call for power storage on a colossal scale. The Waeggital works is the latest and boldest attempt to solve the storage problem. The town of Zurich and the North-Eastern Power Company of Switzerland have combined in an expenditure of over £3,000,000 to store about 50,000,000 kilowatt-hours during the summer months for use in the winter. It has involved huge impounding works for creating a lake storing 140,000,000 tons of water at an elevation of about 1500ft. above the tail race of the lower power station.

These works are a fine engineering feat. Whether they are a fine piece of economic folly I shall not discuss further than to mention that one does not have to travel far to meet Swiss engineers who regard them in that light. It is certainly amazing to think that in this enlightened age we are still without a neater substitute for a coal pile of 50,000 tons than that of an artificial lake high up in the mountains. It is really humiliating that if there does not happen to be a convenient mountain handy with a large almost closed pocket within its folds, the problem of storing the electrical energy we can release by burning 50,000 tons of coal in any ordinary steam power station cannot possibly be bottled up again for future use for six months or even six seconds. Surely a cheap and neat solution of the storage of power comparable in its compactness with combustible fuel is one of the major engineering problems now pressing for solution.

I have said that Switzerland is the country hardest up against this problem of energy storage. That is the position to-day; but it may be our position to-morrow, for energy storage is the real crux of utilising tidal power.

The Severn Barrage.—If the Severn barrage scheme matures—and the Government Committee charged with the investigation has just declared that a *prima facie* case for it has been made out—we are promised 500,000 horse-power during a ten-hour day, or 30 per cent. more than the power generated by Niagara. This would render the Severn estuary more famous than Niagara or the Rhine, for it would be the first great conquest of tidal power. Recent progress in the design of high-speed water turbines of propeller and Kaplan types render the project more feasible and justifiable than it was even five years ago; but, as I have said before, we lack a cheap and neat method of storing energy; indeed, in a flat, densely populated country like ours, no known method is practicable on the scale needed. Perhaps the chemical engineer will find as satisfactory a way of doing this during the next fifty years as the electrical engineer has given us for transmitting and distributing power since the Institution of Mechanical Engineers first visited Cardiff in 1874. Of one thing we may be certain: mechanical engineering will be even more indispensable than it is now, for mechanical engineering is not so much a particular way of doing things, as an essential essence without which no industrial application of science can proceed.

I

An Aerial Mapping Camera.

No. I.

We recently had an opportunity of inspecting the working mechanism of a camera which has been specially devised for automatically taking aerial photographs for map-making purposes. This camera, of which we give a half-tone engraving below, together with a reproduction of a typical photograph, is being put on the market by Vickers Ltd., of Westminster, and is made by the Williamson Manufacturing Company, Ltd. of Litchfield-gardens, Willesden-Green, N.W. 10.

The outstanding features of this camera, as compared with previous apparatus for the same purpose, are the use of roll film, instead of plates, and the provision of an automatic control, which when once set continues to make exposures at the desired intervals until the spool of film is used up. As will be noticed from the photograph which we reproduce, the machine also gives a photographic record of all the data necessary for collating the series of photographs to form a continuous map. Besides performing all these functions automatically, it is possible to take what might be described as "snapshots" manually between the intervals of the main series of photographs. As will be readily understood, the mechanism for performing all these operations is rather complicated, and we intend later to explain the action of the principal parts, but before going on to do so it may be best to deal with the camera itself.

As will be seen from the engraving, the camera comprises two aluminium boxes, the upper one of which is the film magazine, and a metal cone for carrying the lens. The focus is fixed and so is the duration of the exposure, but the amount of light admitted to the film can be controlled by means of an iris diaphragm. A series of lenses having focal lengths of 7in., 10in., 14in. and 20in., all with an aperture of F 4·5 is provided. The film is 9in. wide, and each of the photographs measures 7in. by 7in., the difference in width being accounted for by the record of particulars of the view taken. The length of the film is 65ft., which is enough for 100 exposures, and it will form a continuous strip map that may cover anything from 100 to 500 miles of country, according to the elevation from which the photographs are taken.

The shutter is of the focal plane type, that is to say, it comprises a blind, arranged immediately in front of the film, with an opening $\frac{1}{4}$in. wide cut across its width. At the moment of exposure this blind is drawn rapidly across the film by a spring, so that the rate of exposure is a function of the width of the slit and the speed of the blind. In the case under review the actual exposure is $^1/_{80}$ second. After the exposure has been made the blind must be drawn back again to the starting point or re-set, and it is obvious that if proper precautions were not taken that a second exposure would then be made. There is, however, a second blind that moves forward first, during the re-setting, and covers the slot, so that no light can pass. On the return movement for making the exposure the secondary blind retires first to uncover the slot.

The operation of pulling the blind back to re-set it is carried out automatically by a little electric motor, and we found on timing the machine that only $4\frac{1}{2}$ sec. are occupied in the process. In the event of there being no current available for working the motor, the gear can be driven by a little windmill set in the slip-stream of the aeroplane, or it can be worked manually by a handle on the side of the camera.

In normal working the shutter is, of course, re-set immediately after every exposure, and then awaits the automatic apparatus which trips it to make another exposure after the country covered by the first photograph has been traversed by the aeroplane. The interval between these successive exposures is under control, as it must be, to accommodate the speed of the aeroplane and the altitude, and the method of obtaining this control will be described subsequently; but the interval between the re-setting of the shutter and the next automatic exposure may be anything from 20 sec. upwards. During this interval the shutter may be tripped manually by means of a distant control, to give an additional picture if the operator thinks it desirable to do so. The only condition governing this process of making intermediate "snap shots" is, of course, that the shutter should have been re-set since the last exposure, and in order to ensure against the possibility of the operator trying to make an exposure prematurely, there is an indicator in the control cabin that shows the word "Set" when the camera is ready for another exposure.

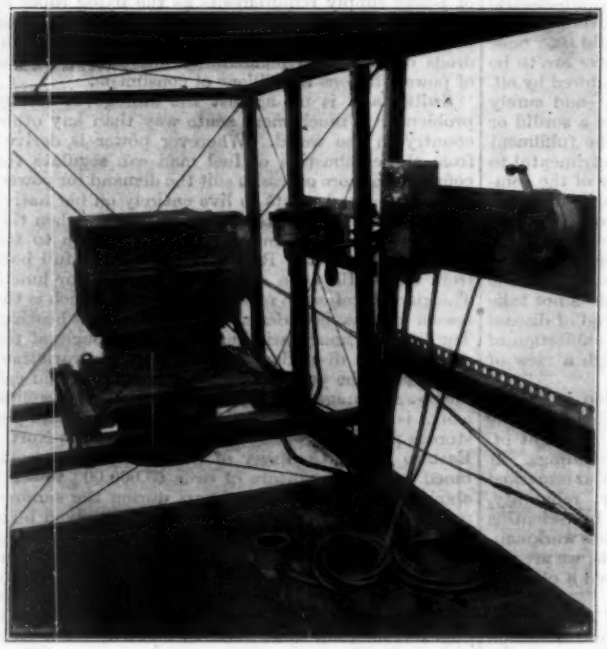
Such individual exposures may be made necessary by a variety of accidents, such as the aeroplane running into a cloud just at the moment of serial exposure or a bad "bump" in the air, but there is a further insurance against the latter trouble in that a red lamp is illuminated in front of the pilot about 5 sec. before any of the automatic exposures, to warn him to keep the aeroplane on as "even keel" as he possibly can.

Reverting to the photograph which the machine takes and the typical example which we reproduce, it will be noticed that in the upper right-hand corner there is the image of an altitude meter, or rather aneroid, that records heights up to 15,000ft. Next there is a series of figures corresponding with the serial number of the photograph. Then there is shown a pair of spirit levels to indicate the angular direction of the film when the exposure was made. Still further down there is a number plate, for identification purposes, and finally the face of a watch to give the actual time of the exposure.

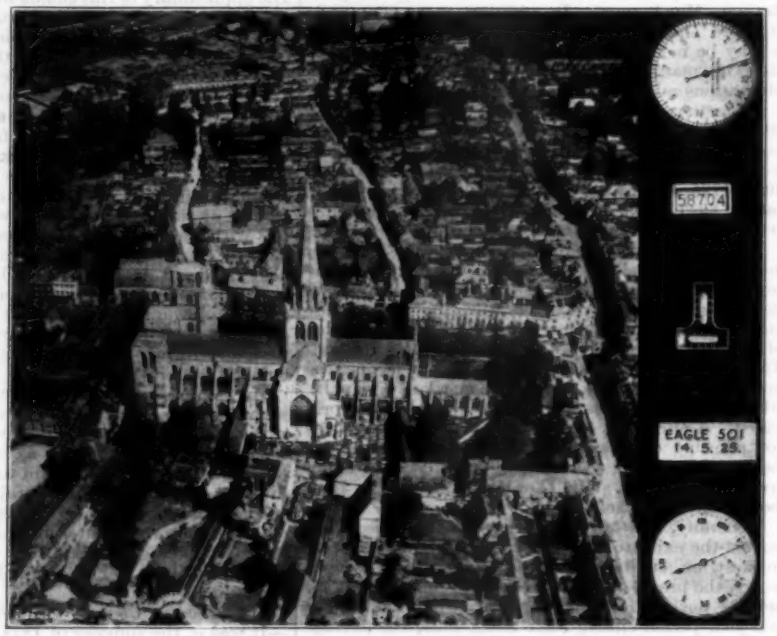
The instruments for making these five records are all arranged in a narrow box fixed inside the camera casing and above each of them there is a 1in. F 3·5 lens, which focusses their images on the film above. Each of the instruments is also illuminated by a little "pea" lamp, and the current for this purpose is automatically switched on just before the exposure is made. Incidentally, it may be mentioned that these lamps are over-run some 50 per cent. to produce as actinic a light as is possible.

The camera itself ranges in weight from about 42 lb. to 51 lb., according to the lens adopted, and naturally needs a fairly substantial support. The general scheme of the foundation can be followed in our engraving, and it embodies movements for training the camera in several directions, while buffers are inserted to minimise the vibrations of the aeroplane fuselage.

Before going on to describe the details of the control mechanism it may be worth while to mention the fact that the whole assemblage is made up of self-contained units, which can be easily detached for overhaul and their places filled at any time by other units taken out of stock, so that in the event of an accident to the machine there is a minimum of delay before work can be carried on.



MAPPING CAMERA APPLIED TO AEROPLANE



REPRODUCTION OF TYPICAL PHOTOGRAPH

Wireless Developments.

In dealing with the general development of wireless during the last twelve months, in an address delivered before the Wireless Section of the Institution of Electrical Engineers, the new Chairman of the Section, Professor C. L. Fortescue, said that the outstanding feature in this country had been the putting into commission of the Rugby wireless station, which stood as an example of scientific principles truly and properly applied to practical problems. Built in the light of the combined experiences of all the services and with the expert scientific advice of a Commission, it approached very closely to an engineering ideal.

Turning to the broadcasting service, Professor Fortescue remarked that probably it would never be possible to ascertain the whole part played by that service during the general strike, but it could safely be said that it was the only means by which the Government was able to maintain contact with the country as a whole during the early days of that remarkable experiment. Another development likely to be associated with the past twelve months was that of the transmission of radio pictures. The value of a service of that nature for journalistic and commercial purposes was at present scarcely recognised, but the day might not be far distant when it would be more economical to transmit a sheet of printed matter as a picture than as a long telegram in Morse. Closely allied to the transmission of pictures was television, a development perhaps of more value to the fighting services than for civilian use.

Professor Fortescue then went on to give a critical review of the developments of the last seven years. Short-wave transmission—that was to say, transmission with frequencies above about 3,000,000 cycles per second—had been used for short ranges before the autumn of 1919, but the development of that system for longer ranges and particularly the establishment of beam stations, had been carried out wholly during the period under review. New problems arose, and it had been necessary to apply many old optical principles on a new scale, with the result that stations were now in existence which radiated more than 80 per cent. of their energy in a beam having a dispersion of no more than 15 deg. The generation of the high-frequency currents called for modifications in the construction of the valves, owing to the large capacity currents to the electrodes, generally far exceeding the currents arising from the streams of electrons within the valve.

The modulation of the high-frequency current in the transmitting aerial, whether for Morse signalling at either high or low speed or for telephony, had been perfected in detail. The demand for true rendering for broadcasting had given rise to close attention to microphones, land lines and accessory apparatus. Microphones now available were less sensitive than those previously in use, but they gave results of a different order of perfection from anything that had been produced before 1919. Those microphones and their amplifiers were unfortunately too complicated for ordinary line telephony. Whether, however, the results heard daily by many millions of listeners-in would shortly lead to an insistent demand for an equal degree of perfection in the public telephone service was a question that might well be exercising the minds of telephone authorities. As regards purely theoretical aspects, it was customary to think of all forms of modulated currents as consisting of a carrier wave and appropriate side bands. The distribution of magnitude of those side bands, which in most cases extended over an infinite range of frequency, determined the width of the band of frequency required for each line of communication. Hand-speed Morse with a continuous wave required only a narrow band. High-speed Morse and telephony had a wider spread of the side bands and spark transmission involved the widest band of all.

Whilst dealing with the transmitting medium, Professor Fortescue remarked that the whole subject of the bending of wireless waves was happily one in which the mathematical physicist, the geo-physicist and the wireless engineer were closely collaborating, and there was little doubt that the combined effort would lead to more

accurate knowledge which would be of great importance.

During the past seven years receiving stations and receiving instruments had been improved in detail, but there had been no great innovations. The manufacture of small receiving valves had so developed under the stimulus of broadcasting that the possible production in Europe and America was now at least 100 times greater than it was in 1919. That result was not merely attributable to the multiplication of manufacturing facilities, but it was brought about mainly by the adoption of improved methods. The greatest factor probably was the use of chemical means for absorbing the last traces of gas, after sealing off from the vacuum pumps.

That reduced the time necessary for pumping and avoided the risk of damaging the filament by positive bombardment. Low-temperature filaments with surface layers of high emitting power were almost universally used, with the result that whilst a life of 1000 hours was once optimistically hoped for, a life of 10,000 hours was now a matter of routine experience. The probable life of some valves on the market at the present time could not be stated, for sufficient time had not elapsed since the new manufacturing processes were introduced. The greatly reduced power consumption of modern valves was perhaps even more important than the life, for whereas a modern filament required a heating power of only ·25 watt, the early valves absorbed from 2 to 2·5 watts. In spite of those improvements, however, there was every reason to expect further developments in the design of receiving valves. The advantage of low internal resistance had not as yet been fully realised, and for many purposes a further reduction was desirable. Moreover, the worry and unreliability of accumulators and primary batteries pointed clearly to the necessity in broadcast receivers of adopting some simple means of obtaining the necessary power from the ordinary supply mains. When that was done a broadcast receiving set, giving a choice of programmes, would become as much a part of the normal equipment of a house as an electric radiator or gas cooker.

In spite of the enormous amount of work that had been carried out in connection with the development of loud speakers, it was apparently a fact that there was no loud speaker in existence that would give a true rendering of both speech and music. Some instruments unduly accentuated the low tones, whilst others had natural resonance above a frequency of 1000. None gave a uniform response over the whole range. That amplifiers were often the source of distortion was undoubtedly true, but the cause of that was easily overcome, when cost was not a serious consideration. But no expenditure within reason could avoid the defects of the loud speaker, and it was a serious reflection on the ingenuity of the wireless engineering profession that that should be the case.

In 1919 broadcasting as it was known to-day was non-existent. There had been, it was true, instances of wireless transmitters being used for simultaneous communication with several receivers. Moreover, both during the war and after several large wireless stations issued lengthy messages in Morse each day, and they were received over the whole world. But those messages were not received by private persons to any appreciable extent, and the full possibilities of broadcasting were certainly not recognised. Both in America and Great Britain amateur interest after the war very naturally centred on wireless telephony, owing to the greater ease and rapidity of communication. The possibility of talking to friends many miles away without connecting wires and with better articulation than that given by the ordinary land line telephone exercised an extraordinary appeal to the popular imagination. Looking back, it was astonishing that what was in the first instance little more than an appeal to the imagination of a comparatively small number of people should have developed in less than five years into one of the common amenities of life, to be found in every home and giving rise to a new industry of no small dimensions.

The problem of programmes would not, however, be solved to everyone's satisfaction until every broadcast receiver gave a choice of at least three stations. With expensive receivers that was already possible almost everywhere, except in close proximity to the transmitting stations—a reservation that seemed to indicate that the practice of placing stations in the most densely populated areas might have to be modified in the near future.

Books of Reference.

"The Trade, Industries, Products and Resources of South Africa and Adjacent Territories." A business and general handbook, 1926. Compiled from official sources by C. W. Francis Harrison, F.S.S., F.R.G.S. Pietermaritzburg: Printed and published by the Natal Witness, Ltd. Price £1 1s. net.—The third edition of this book is now to hand; it is larger and better than its predecessors and a complete index has been added. To conform to the new classification the trade statistics sections have been re-arranged and many new headings appear, whilst the new Customs tariff, preferences and rebates are printed *in extenso*. A great deal of information has been added for the use of prospective tourists in South Africa, and in many cases pictures have been incorporated to augment that information. A special feature of the current issue is an illustrated record of H.R.H. the Prince of Wales's tour of South Africa, written by Mr. J. S. Dunn; all statistics and information have been obtained from the official departments. The book is one which will prove useful to British firms which have dealings and connections in South Africa.

"Motorship Yearbook." Fourth edition. *Motorship*, 220, West 42nd-street, New York, N.Y., U.S.A. Price 3 dollars.—This volume is a well bound and pleasingly illustrated handbook of 208 pages with over 150 pages of editorial matter. In the first chapter the superiority of the motor ship is asserted and twenty-eight reasons are adduced for the increased adoption of motor-propelled vessels. After reviewing progress in the world's motor shipbuilding, an illustrated account of varying types of motor ships is given. Progress in engine design is then discussed, along with the merits of direct and indirect forms of propeller drive, after which various designs of marine oil engines are described and illustrated. Such matters as engine-room and deck auxiliaries are then dealt with, in which section of the book chapters are to be found on new navigational safety appliances and machinery details. The rules which govern the granting of motor ship licences and particulars of engineers' examinations are also given. In the section which deals with fuel oils the U.S. Federal Oil Specifications are reproduced, and there are chapters on the conversion of viscosity values and the specific gravity of various classes of oil fuel, along with a list of the oil fuel bunkering stations at different parts of the world. Another useful list which we understand is published for the first time gives particulars of the world's radio beacons, while there are also wind force and speed tables and metric conversion tables. An interesting part of the book is the detailed record of all motor vessels propelled with engines of more than 300 shaft horse-power which have been constructed during the period 1904 to 1925. The ships are arranged in alphabetical order and also according to the year in which they were built. The volume is one which contains much of interest and value for the motor ship builder and user, and all interested in the future of the marine oil engine and its various applications.

"Hütte" Des Ingenieurs Taschenbuch," Vol. II., 1926. Wilhelm Ernst und Sohn, Wilhelmstrasse 90, Berlin, W. 66. Price 14·70 R. marks.—This second volume of the Jubilee edition of "Hütte," published by the Akademischen Verein Hütte E.V. Berlin, has, like the first volume, been entirely revised and brought up to date. There are five main sections, which are devoted to machine details, prime movers, machine tools and appliances, lamps and illumination, and electro-technics. In the first section account has been taken of newly introduced standards, and fresh material has been added to the chapters on the friction of bearings, gears, and belt drives. The chapter on the control of machinps consists of two parts dealing with vibration, balancing and damping, and the regulation of pressure, speed and temperature respectively. In a preface to the second section short chapters are introduced on human physiology as applied to engineering, energy and its economics, and wind turbines. The main parts of this section are devoted to boilers, steam reciprocating engines and turbines, internal combustion engines, and gas and water turbines. There are four parts to the third section of the book, which are devoted to machine tools and workshop appliances, lifting appliances, and the transport of materials, pumps, and blowers, and compressors for gas and air. This section is framed on generous lines and is well illustrated by drawings. New material has been added to the fourth section on lamps and illumination, which is divided into three parts dealing with photometry, the sources of light, and the design of lighting schemes. The fifth and last section of the book on electrotechnics is again subdivided into eleven chapters, comprising sections on fundamental laws and units, primary and secondary batteries, generators and motors, and transformers and rectifiers. The chapters on testing include measuring apparatus and the testing of alternators and generators. The requirements for economical distributing and switching are also discussed, and the section closes with a long chapter on the electrical heating of liquid, gaseous and solid bodies. There is a useful appendix of the alphabets of various European countries, as well as a general index. In all there are some 1187 pages.

The 1926—the seventeenth—edition of "Kelly's Directory of Engineers, Iron, Metal and Motor Trades" has recently been published. This directory embraces England, Scotland and Wales, and the principal places in Ireland, the Channel Islands and the Isle of Man. It contains the names of those engaged in the many activities in the various trades indicated by its title, both the manufacturing and selling branches being dealt with, there being altogether some 1700 headings. The book comprises:—(*a*) The names for each county arranged alphabetically under the towns and villages; (*b*) an alphabetical classification of trades for the London Postal District, arranged with the names under each trade heading in alphabetical order; (*c*) a similar classification of trades for the rest of England, Scotland and Wales; (*d*) an alphabetical list of the names of some 10,000 branded articles and specialities used in the engineering and allied trades, together with the names and addresses of the manufacturers; (*e*) an alphabetical list of the names, with addresses, of the manufacturers of iron and steel sections, together with the sizes, &c., made by each; and (*f*) a list of various brands which appear on iron and steel work, together with the makers' names and addresses. The book is published by Kelly's Directories, Ltd., 186, Strand, London, W.C. 2, price 45s. net, post free.

THE ENZA POWER AND IRRIGATION PROJECT.

The Enza torrent forms the boundary between the Italian provinces of Parma and Reggio Emilia. The administrations of those two provinces have jointly undertaken a project of water storage for power and for irrigation, which is interesting as being at once typical of its class and notable for certain features which the local conditions have suggested.

The catchment of some 260 square kilometres lies at an average altitude of 910 m., the highest portion being at 2017 m. In a ravine a little below the confluence of the Loma torrent with the Enza a dam 53 m. in height will store the run-off of that area in a reservoir of 60 million cubic metres capacity. The site is about 45 kiloms. from Parma and 38 kiloms. from Reggio. This will be a multiple-arch dam, and between two of its buttresses there will be a power plant of about 30,000 kilowatts capacity. Immediately below this dam the tail-water and overflow will be received in a reservoir of 2 million cubic metres capacity, formed by a dam 20 m. high situated about 1 kilom. downstream. About 2 kiloms. further downstream the water from this reservoir will be utilised in part by a power station supplied through pressure pipes under a head of 40 m., machinery for 3600 kilowatts being provided. It is intended, however, to utilise only the dependable minimum flow of 8 cubic metres per second, giving 2500 kilowatts.

A diversion weir near Guardasone, at a considerable distance downstream from the lower reservoir, will utilise this flow, and that due to the affluent streams of the intervening stretch of the Enza, for the irrigation of extensive areas in the provinces of Parma and Reggio Emilia, 4100 hectares in the former and 7200 in the latter. The soils and crops are such that a duty represented by some 13 waterings of 7 cm. each is expected to provide effective irrigation. The larger dam will be 275 m. in crest length, the arches inclined at about 45 deg., the buttresses 90 m. wide at the base and 6 m. at the top, carrying a roadway of the same width. Both the arches and the buttresses will be of reinforced concrete, the weight of steel per cubic metre in the former being 6 kilos. The spillway has a capacity of 1000 mecusecs.

The lower dam is of the same type, the crest length 180 m., the middle 120 m. being a spillway. The reservoir will effect the daily regulation of the tail-water flow from the main power-house in the large dam, furnishing at the same time a constant flow of 8 mecusecs to the lower power station and for irrigation.

The project is described, with a map and tables relating to the two irrigation systems, in *I Lavori Pubblici*.

Letters to the Editor.

(*We do not hold ourselves responsible for the opinions of our correspondents.*)

THE FLEITNER RUDDER.

Sir,—I am indebted to Mr. Best for his information re the practical application of this invention, but I must contend that its partial balancing merely mitigates the demand for power to operate it, and the fact still remains that a similarly balanced rudder, if positively operated, may attain to any angle, while the Otter Board method of control limits the angle attainable to the resultant of all the forces in action, as we all know an Otter Board cannot be worked "dead to windward."

I am surprised to learn that sea-going craft of 12 knots can turn in twice their length with this system of steering, and think possibly Mr. Best refers to the old tugmaster's method of backing and filling on one helm, by which in some cases it was possible to turn a single-screw boat in a very small space, or possibly they possess an unusual underwater design for some special purpose.

I readily appreciate that the extremes of helm position may be attained within the minimum period, but what angle of main rudder plane to keel line does "hard over" signify in the case of a Flettner rudder? The smaller the arc swept the less time will be taken, also the power available may be considerable, but it has to be paid for, which is the whole object of my criticism.

Mr. Best admits that it is the slip stream from the propeller or the flow past the rudder that operates the device, and as in both cases these flows are derived from the main propulsive agent, it is the propulsive power that must suffer to the extent of the drain upon it for steerage purposes.

The rudder will be undoubtedly popular with barge skippers, particularly if not their own owners, since it saves them the labour of steering; but what is the effect on the tug's consumption? This is a test I suggest it would be worth making very thoroughly. The interest in the invention lies in the subtle nature of the forces involved which lend themselves to deceptive argument; but in that it claims, I understand, to reduce the power needed for steering—I decline to admit it—it transfers some of the power needed for operating an ordinary rudder from the human or mechanical helmsman to the main engines, and if this is a net gain, let it be conceded; but it does this at the increased cost of installation and complication and to some extent recalls the man who cut two holes in his hen house door, a large one for the hen and a smaller one for the chickens. It is difficult to see on paper where it is superior to a well-balanced rudder positively controlled

London, November 6th. Stanley P. Christie.

"TIME IS MONEY."

Sir,—The system of remuneration so admirably described by Mr. Perry-Keene in your issue of October 29th is doubly right, in that increased effort is recognised adequately and promptly. The absence of sharing the time saved—an unnecessary piece of self-deception, because, whatever the share may be, the workman expects his time and third, and consequently the time allowance must always be exaggerated to include this condition—makes the works part of the system practically straight piecework and therefore easily understood by the men.

The standard of double time, which the least efficient is expected to reach, would seem to make the earnings of the other men somewhat extraordinary, unless, indeed, the works are organised on Ford lines, in which the individual must keep up with the procession.

It is not easy to agree with Mr. Perry-Keene that no reduction in the time allowance should be made when the workman is provided with improved facilities. No doubt it is a proper thing that his earnings should be improved, to show that new methods are of immediate general benefit, but the most unreasonable Socialist could hardly charge one with want of faith were the improvement to range between 10 and 25 per cent. There must be many cases where Mr. Perry-Keene's rule would prohibit the introduction of a new tool. The cost, too, of working a new method is not always at first apparent.

It would be interesting to learn if the general labourers are paid on a piecework basis, and also, of much greater importance, the foremen, especially having in mind the high earnings of the men.

In most works the foreman has the double duty of getting his arranged output and of keeping step with other departments. The importance of team work amongst foremen, particularly in a works of general manufacturing character, is, of course, well known. This is best recognised by a bonus on total rather than departmental output, and there is a fascinating range of ways in which this can be done.

The one choice not to be made, at least in engineering (to keep to things we know about), is profit sharing, even where there are profits to be shared. The works duty lies with output, not profits. Robert True.

Thorpeness, November 3rd.

New Works at Cheadle Heath of Henry Simon, Ltd.

With conditions as they are at present, to enter upon extensions of old factories requires more than the average amount of courage on the part of engineering firms. Still more does it demonstrate faith in its products when we see a firm discarding its existing works and launching out into a brand new factory, such as that which Henry Simon, Ltd., Manchester, has recently erected at Cheadle Heath. It should be mentioned that for some years this enterprising firm has been handicapped with regard to its manufacturing facilities by the fact that its operations had to be carried out in two distinct factories, one at Stalybridge and the other at Bredbury, both of which were controlled from a head office in Manchester. Both these works were capable of turning out a large volume of machinery, but they were not arranged to the best advantage. For many years the concentration of the two factories and the necessary administrative departments into one large factory has been a subject for consideration, and in 1923 the directors decided that the time had come to make a move. In making this decision they were influenced by the knowledge that what they proposed to do would help to relieve the unemployment in the engineering trade, and it was also hoped that the new works would be ready and in running order in time for the next trade boom, which many engineers are anticipating.

Mr. C. Bentham, M.I. Mech. E., the managing director, who is responsible for the design and lay-out of the works, visited many factories, both at home, on the Continent, and in the United States, to obtain ideas, and the result of his efforts can be judged from the description which follows. We have paid several visits to the works, and have been favourably impressed by the straightforwardness of their lay-out and equipment, as well as by their cheerfulness, and by the pleasantness of their surroundings. With a cricket ground, bowling green, hard tennis courts and a miniature golf course all on the company's own land, there is ample choice for all who engage in outdoor sports to enjoy themselves in healthy recreation.

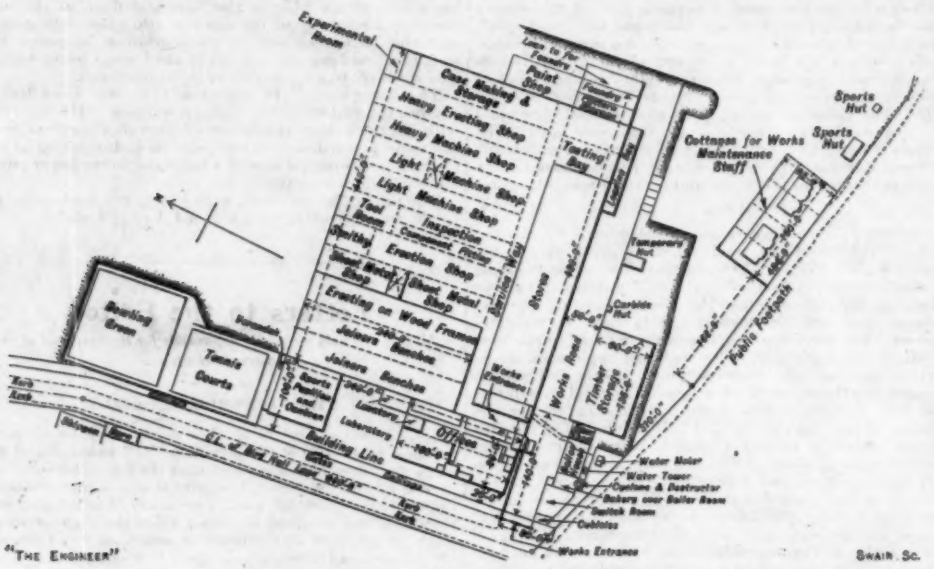


FIG. 1—PLAN OF THE NEW WORKS AT CHEADLE HEATH

The firm's activities are chiefly concerned with flour and rice milling machinery and conveying plant of many kinds, and these products involve the employment of workers in many different trades, of which wood-working claims a large percentage. In the general lay-out the firm's objective has been the co-ordination of a number of separate factories into one complete unit under one roof. The separate sections may be classified as follows:—(*a*) Joiners' shop, in three sections, namely, machinery work, bench work and assembly; (*b*) sheet metal department, in two sections, namely, black iron sheeting and tinsmiths' work; (*c*) machine shop; (*d*) fitting shop; erection shop for iron-framed machines; (*e*) paint shop and packing department. In addition to the foregoing, there are other smaller sections namely, a blacksmiths' shop, a foundry, pattern stores, an emery filling shop, a testing stand, and an experimental room. The principal connecting link throughout the whole of the works is the stores, which, as will be seen from the drawings—Figs. 1 and 2—extends along the whole of one side of the works, with the various departments arranged at right angles to it, so that the products of any one department can be passed into store and retained until required by some other department to which they can be passed out with a minimum of handling. Outside the wall of the works which forms one side of the stores the main works road and yard extend throughout the whole length. This side of the structure is composed of a series of large sliding doors to enable incoming goods to be discharged at any desired point. Inside the works and between the stores and the workshops a service road, 20ft. wide, extends throughout the whole length, and sliding doors are provided in the stores opposite each main bay.

The total area of the site is 23 acres, and the area in use is 5 acres, including outbuildings, roads, &c., the area covered by the main building being 4 acres. The works are laid out all on one floor in order to facilitate communication between the various sections, and at the same time permit of the rearrangement of plant to be readily made if desirable. The only restriction to such rearrangement is the brick wall round the joiners' shop, which was necessary to keep down fire insurance rates.

Materials and light machines are run about on low trolleys without recourse to much overhead lifting apparatus. The heating of the shops is effected by hot water pipes overhead, in order to keep the floor space clear of obstruction, the hot water being supplied by a battery of boilers fired by refuse from the wood-working shops. The excellent lighting effects are assisted by adopting paint of a blue-green colour throughout.

Power.

Power is obtained from the Cheadle Council, which, in turn, gets its supply from the Barton Power Station of the Manchester Corporation, current coming on to the site at a pressure of 6000 volts and being transformed down to 500 volts alternating three-phase for distribution throughout the works for power and 200 volts for lighting.

The switchboard and transformer are contained in a separate switch house at the opposite side of the road to the shops, and the cables are taken under the ground through ducts to the various section or distribution boards throughout the works. An interesting feature of the switchboard is the provision of an alarm so calibrated as to cover both power and lighting demand and ring a bell when the demand exceeds a predetermined figure. This provision is necessary for economical working when the supply is on the maximum demand basis. In case of an excessive demand for current occurring steps are at once taken to find the cause, and, if necessary, one of the less important sections is shut down until the demand becomes

NORTH SIDE
SOUTH SIDE
(ELEVATION FACING BIRD HALL LANE HIGH BAYS IN BACKGROUND NOT SHEWN)
EAST ELEVATION
CROSS SECTION (LOOKING EAST SHEWING GLAZING IN HIGH BAYS)
ELEVATION FACING WORKS ROAD (SOUTH ELEVATION)
NORTH ELEVATION
LONGITUDINAL SECTION (LOOKING NORTH)
WEST SIDE FACING BIRD HALL LANE
EAST SIDE
"THE ENGINEER"
SWAIN Sc.

FIG. 2—ELEVATIONS AND SECTIONS OF THE BUILDINGS

normal. There is a fifteen minutes' interval in which to make these adjustments.

Generally each shop has a power feeder of its own, and at the head of the shop a remote trip switch is arranged for cutting off the whole of the power in that shop in case of emergency. Squirrel-cage motors are employed generally, and in the wood-working shop they are accommodated under the floor so as to avoid obstruction by belts. In the machine shops the machines are driven in small groups and obstruction is obviated by raising the motors on stands built up of steel angles and about 5ft. high.

Artificial Lighting.

The artificial illumination of the shops is carried out by skirted reflectors so as to reduce glare, and this effect is further assisted by the bottom half of the lamps being sprayed. The size of unit adopted is 200 or 300 watts, according to the particular requirements, and the fittings are arranged so that correct focussing of light is obtained whichever size of lamp is used. The switches are grouped so as to centralise control and are of the ironclad pattern. Plugs for hand lamps are fitted at convenient points along each shop. In the offices the lighting is by enclosed type lamps with fittings for 200-watt globes. The object has been to spread the light of the lamp over a large area and give ample diffusion, so as to reduce shadow intensity. At the same time efficiency has not been lost sight of; three-ply glass is used, which allows a very thin section of opal to be used without making the glass too fragile.

A special feature of the shop lighting system is that each shop has its own three-phase feeder, and the lights in that shop are balanced so that any one shop working overtime will not cause an unbalanced load.

Constructional Details.

In the construction of the buildings Messrs. Simon have adopted plain and straightforward lines. There is no striving after architectural effect, and as the output of the works comprises no very heavy machines the framework is of light section. The offices are extremely light and airy, but there is a marked absence of luxurious furnishings and carpeted floors. The main works buildings consist of eight bays with a clear height of 14ft., each 40ft. wide by 340ft. long, and three high bays, served by Heywood's 5-ton electric cranes, each 40ft. wide by 360ft. long and one bay 180ft. long.

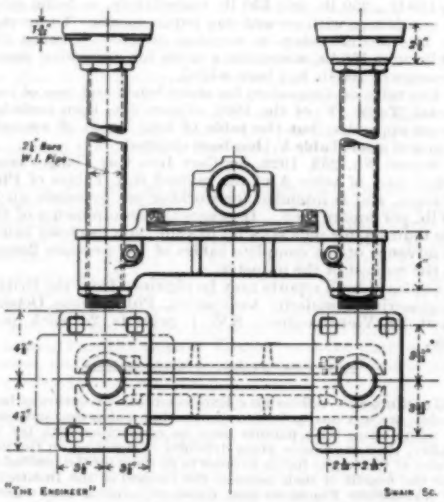


FIG. 4—ADJUSTABLE HANGER FOR SHAFTING

The framework of the buildings is of steel. It consists of lines of girders carried on H section stanchions in the low bays and lattice stanchions in the crane bays. From these joists are carried the roof principals, which are of the north light type throughout—Fig. 3. In the machine shops the tie angle is replaced by a light trimmer joist to carry line shafting. In between these trimmers are arranged further trimmers dividing up the overhead steelwork into bays 10ft. square. This arrangement of overhead steelwork combined with a special type of hanger—shown in Fig. 4—designed by the firm, standardises the whole of the overhead equipment. The chief feature of these hangers is the provision for vertical adjustment, which comprises two lengths of wrought iron tubing 2¼in. internal diameter, with screwed ends and nuts, by which the cast iron bottom sections carrying the pedestals can be raised or lowered as required.

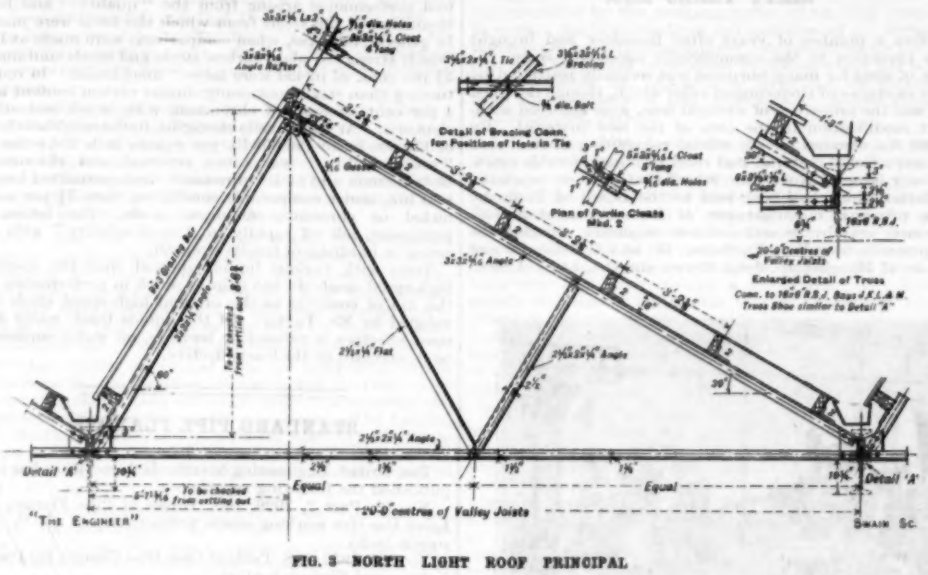


FIG. 3—NORTH LIGHT ROOF PRINCIPAL

There is nothing special about the foundations for the stanchions. They are chiefly concrete blocks of the requisite depth and spread, the subsoil being of hard clay, with here and there a pocket of wet sand. In one or two places the pockets were about 10ft. deep, and there the concrete blocks were carried down to solid clay. The footings for the walls throughout are of concrete, and where the subsoil was of a sandy nature, or over filled ground, they are reinforced to form concrete beams, concrete blocks being carried down to solid clay where necessary to support the load.

The south slope of the roof is covered with three-ply roofing felt, laid on 1in. T. and G. matchboarding. The north slope is covered with ¼in. rough-rolled glass and lead-covered steel glazing bars. The area of glass is exceptionally large for this class of roof. Hinged ventilators, worked in sets of twelve by special gearing, are arranged as part of the glazing. A ventilator giving an opening of 2ft. 6in. by 2ft. is set every 10ft. By means of these openings a very even distribution of fresh air is obtained.

Lines of cast iron gutters of large section are carried on the valley joists, down pipes 6in. diameter being spaced every 80ft. The gutters are given a fall of 1½in. in 40ft. The joint between the roofing and the gutters is made by carrying the roofing felt down to 2in. from the bottom of the gutter and cementing with a special bitumen compound. On the glazed side lead flashing is carried from the bottom purlin, and the space between the purlin and glass is sealed by a lead wind guard.

The side of the works facing Bird Hall-lane is of red brickwork with a steel framework. Stanchions are cased in brick-forming pilasters, the brickwork is carried above the roofing and finished off with white stone coping. The north and east sides of the buildings are of a temporary nature, the steelwork being designed specially to allow for extension. A 9in. brick dwarf wall, 6ft. high, runs along these sides, and the remaining height to the eaves and gables is covered in with asbestos cement corrugated sheeting. The south side of the works, along which runs the main works road, is closed in with sliding doors for the full length of the low bays. These doors are of steel and glass, steel sheets being carried to a height of 6ft. and glass for the remaining 8ft.

With the exception of the woodworking machinery section of the joiners' shops and the smithy, the entire works floor is covered with Duro flooring composition. It is laid on 4½in. concrete with the exception of the paint shop, where it is laid on wood. The smithy flooring consists of hard bricks laid on edge. In the machine bay in the woodworking shops the ground is excavated below the floor, so as to allow for dust-collecting piping to be carried underneath the floor, and for the motors and countershafting for machines to be below floor level. The flooring in this bay is of 2in. T. and G. boarding laid on 9in. by 3in. timber joists.

The lavatory accommodation has been provided in a novel manner. Four sets of lavatories, arranged in two groups of two sets, are built within the works buildings, the positions being such that no workman has a long distance to walk. To comply with the building by-laws these lavatories are raised up through the roof of the building, as shown in Fig. 5, and are reached by stairways from the various shops, one set serving the joiners' shops, one the sheet metal shops, and so on. The lavatories being within the shops and the stairways visible to the various foremen concerned, no system of checking has been found necessary.

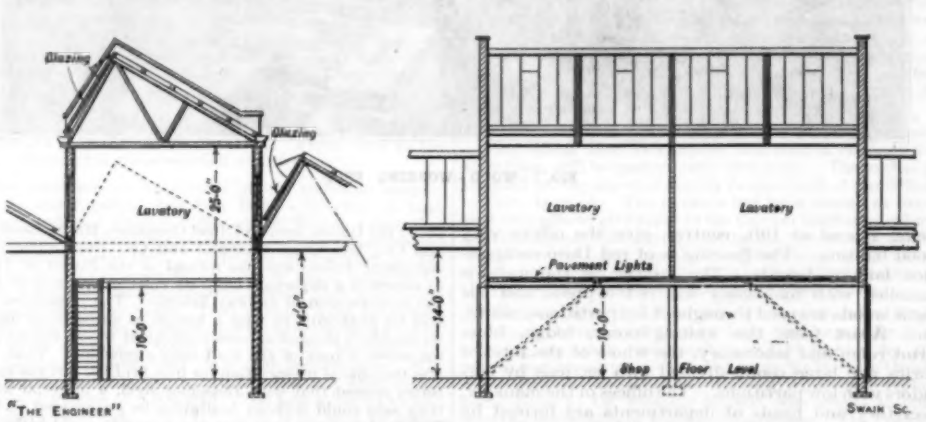


FIG. 5—ARRANGEMENT OF LAVATORIES

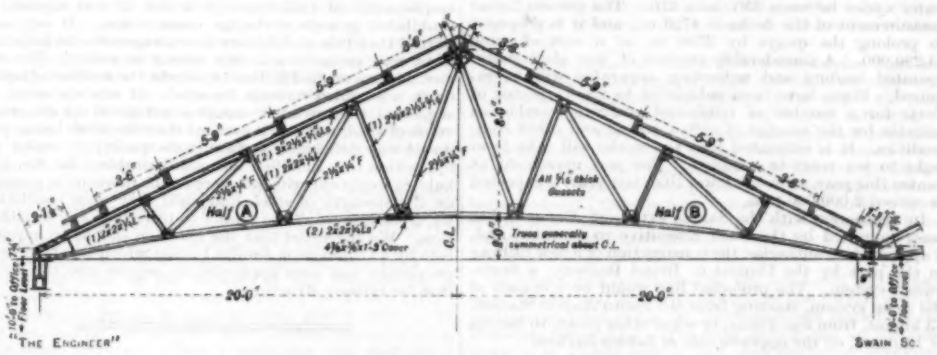


FIG. 6—ROOF PRINCIPAL FOR OFFICE BUILDING

The fire protection within the works is by means of "Firefoam" extinguishers, and laid round the works buildings there is a cast iron water main, with

fire hydrants at suitable points. Hose boxes with fire appliances are set at various places.

Offices.

The office building adjoins the main works building, and is 160ft. long by 80ft. wide. It consists of two bays, each 40ft. wide by 160ft. long and 10ft. clear from floor to the springing of the principals. The framework of the building is of steel, with 40ft. principals at 10ft. pitch. The tie bars of these principals —Fig. 6—are curved to give an improved appearance. The roof is covered with russet brown asbestos diagonal tiles, laid on matchboarding with sacking felt in between the tiles and the boards. On each slope there is patented glazing of the same type as used for the remainder of the buildings, 12ft. wide, running the full length of the building.

The front and sides of the structure are of red Accrington facing bricks, the front wall being carried up above the eaves gutter to form a parapet. Steel section casement windows, 8ft. long by 6ft. high, run along the front and ends of the building. They are glazed with ¼in. polished plate-glass, and, being spaced at 10ft. centres, give the offices very good lighting. The flooring is of red Duro composition laid on boards. The interior of the walls is panelled with mahogany and red cypress, and the same woods are used throughout for partitions, offices, &c. Apart from the waiting-rooms, lodge, blueprint room and laboratory, the whole of the interior forms one large room, divided into sections by corridors with low partitions. The offices of the manager, secretary and heads of departments are formed by partitions, the upper parts being glazed.

Various views of the interior of the works are given herewith and on page 528.

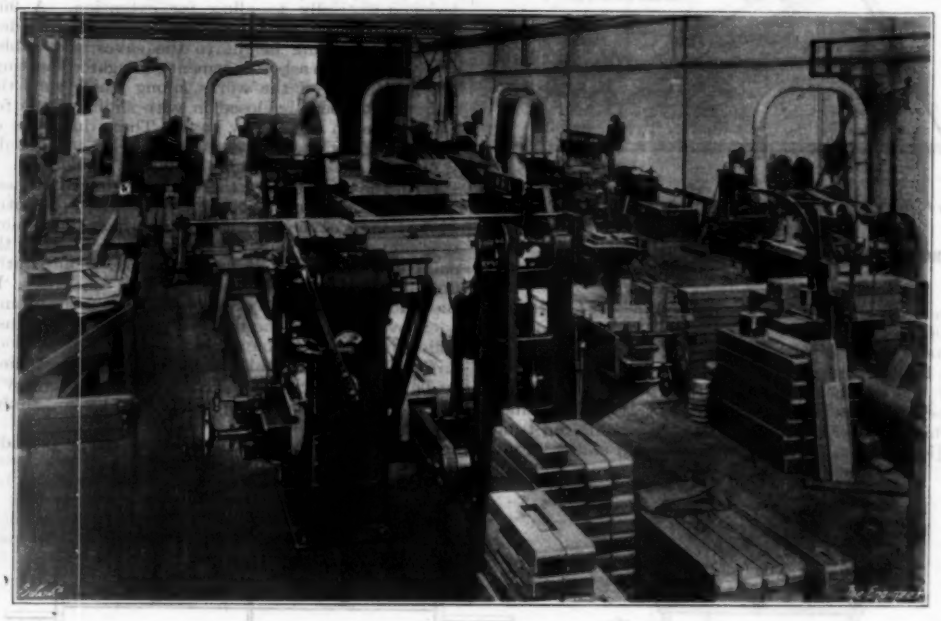


FIG. 7—WOOD-WORKING SHOP

PORT EXTENSION WORKS AT SANTOS, BRAZIL.

A contract has been entered into by the Santos Docks Company for the extension of the port works, including the extension of deep water quays, where the depth of the water varies between 25ft. and 31ft. The present linear measurement of the docks is 4726 m., and it is proposed to prolong the quays by 2700 m. at a cost of some £3,290,000. A considerable amount of new electrically-operated loading and unloading apparatus will be required. Plans have been submitted to the Inspector of Ports for a number of reinforced concrete warehouses suitable for the storage of coffee, wheat and other commodities. It is estimated that the works will take from eight to ten years to complete. The port movement at Santos this year, although lower than last year, is expected to exceed 2,000,000 tons.

In connection with the Santos extension, Congress has been requested by the Chief Executive to consider, and, if approved, to authorise, the construction of a new railway to the port by the Central of Brazil Railway, a State-owned system. The projected line would be a branch of the main system, starting from the Santo Angelo Station, 43 kiloms. from Sao Paulo, or some other point, to Santos of Itapema, on the opposite side of Santos harbour.

The plan, however, is meeting with great opposition from existing railway interests. It is pointed out that, apart from the injury to capital invested in the Sao Paulo-Santos Railway, Sao Paulo, having become the heart of the State's activities, would experience most harmful results from the building of a new line or port connecting with another centre, and two systems of commercial transport would be created to serve the same zone. It is proposed, as an alternative, to substitute for cable haulage up the planes on the "Serra," an important section of the Sao Paulo Railway, an extension of the locomotive traction section, which has been pronounced practicable, although possibly somewhat costly. The advocates of this plan to relieve congestion on the line, caused mainly by strangulation on the cable haulage section, point out that the cost and maintenance of the proposed conversion would be less than that resulting from building a new line or constructing another port.

SIXTY YEARS AGO.

For a number of years after Bessemer had brought his invention to the commercially successful stage, the use of steel for many purposes was seriously restricted by the existence of Government rules which, though designed to suit the properties of wrought iron, were enforced without modification in the case of the new material. By 1866 the demand for the official recognition of steel as a constructional material had risen to a considerable pitch. In our issue of November 9th of that year we reprinted a letter which had been sent to the Board of Trade by the principal manufacturers of Bessemer steel in this country and by several eminent engineers. Among the signatories were Wm. Fairbairn; W. and J. Galloway and Sons, of Manchester; John Brown and Co., Ltd., of Sheffield; the Bolton Iron and Steel Company; Henry Bessemer and Co., and Chas. Cammell and Co., Ltd. The chief complaint voiced was the refusal of the Board of Trade to sanction a departure from its rules in connection with the construction of railway bridges. The inspectors had still no authority to pass a bridge as satisfactory unless its members showed an area equivalent to one square inch for every 5 tons of the load they supported. That rule was the official prescription for iron bridges, but the signatories argued that with Bessemer steel, a material which they said could without hesitation be guaranteed to bear 36 tons per square inch, and which mostly could withstand 44 to 47 tons, the working stress might quite safely be raised to 8 tons per square inch. The benefit to be derived from such an increase was exemplified by a reference to a railway bridge of steel which the London and North-Western Railway had erected at Sankey, near St. Helen's. This bridge being employed only for goods traffic was, by the regulations then in force, exempt from Board of Trade inspection. By the adoption of a higher working stress the weight of the bridge had been reduced to five-eighths of that of a similar iron bridge of equal strength, and, in addition, there had been a consequential saving in the foundations required. So long as the Board of Trade refused to recognise the improved qualities of steel, the employment of that material would, it was argued, be prohibited in railway bridge construction. It was submitted that this prohibition was antagonistic to improvement and progress and was wrong in policy. For our own part we seemed inclined to doubt the wisdom of laying down a modified formula for steel. It was not clear, we suggested, that we knew enough as yet about the structural value of steel, nor was it evident that the steel being produced was sufficiently certain in its quality to render the imposition of a modified formula desirable. At Mr. Kirkaldy's works experiments were at the moment in progress on the strength of steel, and until they were concluded, we argued, it would be unsafe to introduce any modification. We suggested that the question should be inquired into by a Commission similar to that which nineteen years previously had been appointed to inquire into the use of iron for railway structures.

THE ROUGH TURNING OF ALLOY STEELS.

Tests have been made recently by the American Bureau of Standards primarily for the purpose of extending to commercial alloy steels some of the emp rical laws originally worked out by Mr. Frederick W. Taylor, some twenty years ago, in cutting carbon steels. The steels cut included carbon, nickel, low and high chromium, chromium, vanadium, chromium-molybdenum, and nickel-chromium steels having tensile strengths between about 65,000 lb. and 195,000 lb. per square inch. The effect of variation in chemical composition and mechanical properties of the metal cut on tool life, cutting speed and the power required in cutting was determined for the current high tungsten-low vanadium, low tungsten-high vanadium, and so-called cobalt high-speed steels now on the American market. In addition, a study was made of the effect upon tool life of cutting speed, feed, depth of cut, coolant, &c.

Certain measurable differences in "machinability" in rough turning were found for the different alloy steels, but in most cases they were no greater than differences in tool performance arising from the "quality" and heat treatment of the steels from which the tools were made. In general, however, when comparisons were made at low tensile strengths, plain carbon steels and steels containing 3½ per cent. of nickel were more "machinable" in rough turning than steels containing similar carbon content and 1 per cent. or more of chromium, with or without other elements. At high tensile strengths, in the neighbourhood of 175,000 lb. to 190,000 lb. per square inch the order of "machinability" was often reversed and chromium-molybdenum and nickel-chromium steels permitted longer tool life, under comparable conditions, than 3½ per cent. nickel or chromium-vanadium steels. The latter, in particular, fell off rapidly in "machinability" with increase in hardness or tensile strength.

Tests with various liquids showed that the modern high-speed steels do not gain as much in performance by the use of coolants as the original high-speed steels developed by Mr. Taylor. Of the liquids tried, water was most effective in promoting tool life, oil water emulsions next, and lard oil the least effective.

STANDARD PIPE FLANGES.

The British Engineering Standards Association has just published the following reports:—

No. 10, Part 2, 1926, B.S. Tables of Pipe Flanges for Land Use (for working steam pressures up to 450 lb. per square inch).

No. 253, 1926, B.S. Table of Cast Iron Flanges for Pipes, Valves, and Fittings for Gas.

Of these two reports the first is a revision of the flanges for steam originally issued in 1904. Owing to the increasing use of higher pressures the preparation of additional standards to those given in the original publication has been found necessary, and a table for 450 lb. per square inch working steam pressure has been drawn up and is included in the present issue. A table for still higher pressures is in contemplation.

The original tables have been reviewed in the light of the experience gained since they were first published, and a number of modifications have been made. With the exception of the ½in. and ¾in. nominal sizes of the 250 lb. and 350 lb. standards no changes have been found necessary in the flange diameters or both circle diameters. In the original report a number of ranges of steam pressure were included in one table. This had been found inconvenient in practice, and separate tables for each pressure are now given, the tables being designated by letters to avoid confusion with the original tables, which bore numbers. The present publication contains nine tables lettered D to P inclusive.

The limiting working pressure of the original 55 lb. standard has been altered to 50 lb., whilst those of the 125 lb., 225 lb., and 325 lb. standards have been increased to 150 lb., 250 lb. and 350 lb. respectively, as being more in accordance with present-day requirements. To provide an intermediate step in working pressure between the 50 lb. and 150 lb. standards a table for a working steam pressure of 100 lb. has been added.

The table of dimensions for short bends and tees of cast metal (Table IV. of the 1904 edition) has been included as an appendix, but the table of long bends of wrought iron and steel (Table V.) has been omitted.

Report No. 253, 1926, for Cast Iron Gas Flanges comprises part of table A of the revised B.S. Tables of Pipe Flanges, and is intended for working gas pressures up to 30 lb. per square inch. It covers the requirements of the gas industry for pipe sizes up to 48in., and has been issued in advance of the complete tables of low-pressure flanges at the request of the industry.

Copies of both reports may be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria-street, S.W. 1. price 1s. 2d. each, post free.

Training for Automobile Engineering.—Numbers of boys to-day are anxious to become automobile engineers, and since in many cases their parents have no connection with the industry, they experience great difficulty in deciding on the best course of training to follow in order to fit them for the profession. For the benefit of such parents, the Council of the Institution of Automobile Engineers has, therefore, after a very careful study of the whole question, agreed upon a recommended course of training, and has also prepared a list of engineering firms in various parts of the country which have in operation special schemes for the training of lads. Application for advice in this connection (which will be given free to parents), should be made to the secretary of the Institution, Watergate House, York-buildings, Adelphi, W.C. 2. Parents are urgently recommended to give consideration to the training of their boys before the latter have left school, so that the best procedure may be followed from the commencement.

Allen Liversidge, Ltd., London Staff Dinner.—The annual dinner—the sixth since the war—of the London staff of Allen Liversidge, Ltd., was held at the Trocadero Restaurant on Friday last, the 5th inst. As had been done for several years past, this dinner had been arranged to coincide with a sales conference, which the company holds each year, so that its representatives from various parts of the country and abroad who come to town for the conference might have an opportunity of attending the dinner as well. Consequently, a goodly gathering, which included numerous guests, had assembled under the chairmanship of Mr. Henry Stevenson, the chairman of the company. The dinner was excellent, and the speeches—there were but three of them, made respectively by the chairman, Mr. T. G. Allen, joint managing director, and Mr. K. S. Murray, the chairman and managing director of the British Oxygen Company, Ltd., who replied for the guests—were not only commendably short, but also of an order distinctly above the average. The dinner was followed by a dance, and a thoroughly enjoyable evening was spent by everyone, the cordial and close relationship existing between the company and its employees being much in evidence.

Railway Matters.

THE Great Western Railway Company is seeking powers next session to close and abandon the Kennet and Avon Canal. Local opinion holds that a motor road should be constructed on the site.

IT is officially announced by the Great Western Railway Company that Mr. W. L. Monckton, the London divisional engineer, has retired, and that he has been succeeded, as from November 1st, by Mr. R. C. Y. Kirkpatrick, the Oswestry divisional engineer. Mr. S. A. Blackall, assistant divisional engineer, Neath, becomes the Oswestry divisional engineer.

Svenska Dagbladet reports that the Swedish inventor, M. C. G. Blomqvist, of Knivsta, has produced a new type of rail joint which has been tried with success for three years. Negotiations are now proceeding with several railway companies in France and Germany for the purchase of exploitation rights of the invention, which is said to reduce wear on the rolling stock.

SINCE the year 1923 the London and North-Eastern Railway Company has been able, by alterations to roads or signalling, to close seventy-nine signal-boxes, thereby effecting an economy of £33,000 a year. Many such changes will have been made possible by the long-distance operation of facing points, such as was done on the Lancaster and Carlisle line—see THE ENGINEER of June 4th last.

IN this column of our last issue we mentioned certain reductions in the London, Midland and Scottish train services which had been effected in order to economise coal consumption and reduce working expenses. The London and North-Eastern has now followed suit. The Pullman trains to Leeds and to Edinburgh have been combined in one train, as have the 1.30 and 1.40 p.m. and the 5.35 and 5.45 p.m.

SOME very interesting breakdown work was done last Friday and Saturday on the Waterloo and City tube railway. On Friday morning a conductor rail broke and a train came to a stand with a coach spanning the fracture. Power had necessarily to be cut off from the line, and not only had the remaining vehicles to be removed, but the car had to be jacked up in a very limited space before the broken conductor rail could be removed and a new one inserted.

THE railway companies have now won the second stage in the test case as to their ability to increase their charges within the permitted maxima without obtaining the consent of the Railway Rates Tribunal. The Court of Appeal, on November 4th, dismissed the appeal against the judgment of Mr. Justice Astbury that the companies had that power. Should that decision be confirmed by the House of Lords, it will be possible for the railways to raise their rates so as to bring in another £25,000,000 a year.

THE monthly statements issued by the Canadian National Railways continue to show increased earnings and a decrease in operating expenses. The month of September established a new record, with net earnings of 4,915,250 dollars, as compared with 3,940,070 dollars for September, 1925. For the nine months ending September the net earnings amounted to 25,743,334 dollars, as compared with 13,325,762 dollars during the corresponding nine months of 1925, an increase of 13,417,571 dollars.

THE Cardiff Railway was built by the Bute Docks interests at a great expense in order to compete with the Taff Vale. It is under 12 miles in length, and, owing to expensive engineering works, cost £700,000 to build. As a result of the Railways Act the Taff Vale and the Cardiff are absorbed in the Great Western, and a sequel is seen in an announcement in the *Great Western Railway Magazine* for November that "the traffic over the Cardiff Railway section does not now justify the retention of a double track, and the section is therefore to be converted into a single line."

THOSE who take an interest in such matters may have noticed that the Queen of Roumania and her party are travelling in the United States at a nominal charge of 1 dollar per railway used, or 28 dollars in all. As this provokes the inquiry: Why make any charge at all? we would say that under the Railway Rates Act, 1906, any person giving or receiving free transportation in the United States, except a railway company's own servants, is liable to a fine of from 100 dollars to 2000 dollars. The Southern Pacific Company refused to make such a concession, and so the party is not visiting San Francisco or any other Californian city.

SINCE the report by Colonel Sir John Pringle on the collision of May 10th at St. Margaret's, Edinburgh—reviewed in THE ENGINEER of July 16th—was issued, it has been made known that some incorrect evidence was given and a supplementary report by Sir John has therefore been issued. The point related to the switching-out of a certain box and showed that it would have been possible to have maintained block working and not to rely on telephonic communication. What, however, is of greater interest is the statement by the inspecting officer that he did not consider that the accusation made against the men on strike that they refused to assist persons injured in the accident had been proved by the evidence. In this connection we would refer to the statement made in Parliament when it was rising for the Whitsuntide recess, and reproduced on page 581 of our issue of June 4th.

A SERIOUS buffer stop collision occurred at Sligo one evening last week, when the mail train from Dublin failed to stop at its appointed place. Two carriages were telescoped, but only one passenger was injured. The incident ordinarily would not be worth recording, but it serves to draw attention to the rarity of railway accidents in Ireland. There is the same governmental supervision there as in Great Britain, but only one accident—the train blown off a viaduct on the Burtonport Extension on January 30th—was inquired into last year, and a collision during shunting at Greystones on August 6th during 1924. Moreover, since the Portadown derailment of June 30th, 1886—forty years ago—there had, excepting the Armagh disaster of June 12th, 1889, been no accident in which more than two passengers were killed until the above-mentioned accident on the Burtonport Extension. Four passengers lost their lives then.

Notes and Memoranda.

THE sum of £400 is allocated in each calendar year by the Institution of Petroleum Technologists to the advancement of research in petroleum technology and its basic sciences, and the Council is prepared to receive applications for assistance from this fund. Applicants proposing to engage in research in a university institution must be recommended by the professor under whom they propose to work. Applications from full members of the Institution require no additional support. Applications for grants from this fund must be received by the secretary not later than December 1st. Application forms may be obtained from the secretary of the Institution at Aldine House, Bedford-street, Strand.

THE Automobile Association has approached certain shipping companies with a view to the installation of efficient trays and satisfactory means of handling cars, during shipment, with the least possible risk of damage. The antiquated method of slinging by means of ropes through the wheels from the axles has always been a source of anxiety to car owners. Apart from the grave risk of damage to the car and mechanism, the need of some new and quick method is important. The Automobile Association anticipates that as a result of these efforts, a majority of the shipping companies will, in the near future, institute an improved lifting system which has proved most efficient and satisfactory, and has none of the attendant risks of damage prevalent with the old system of slinging.

"TITANITE" is the name given to a new patternmaking material in the form of a kind of stone powder which, when mixed in the right proportions with the proper liquid, can be poured into a mould, and after allowing from four to six hours for setting, will give a pattern plate which in appearance strongly resembles marble, but with a surface which can be readily finished by means of a file or sandpaper. An advantage is that the new material can be prepared in a few minutes, the method of procedure being somewhat similar to the process of making a plaster-of-paris pattern or mould, but without the drawback which attaches to the latter of having to be used the moment it is mixed. Contraction on drying is negligible. The new material has been introduced by the Constructional Engineering Company, Ltd., of Birmingham.

THE effect of the stoppage at British collieries on the coal traffic through the Suez Canal has been very pronounced. According to the official figures, the monthly totals of cargoes of British coal passing through the Canal were 55,000 tons in March, 26,000 tons in April, 11,000 tons in May, 5000 tons in June, 400 tons in July, and none either in August or September. As compared with a monthly average of 50,000 tons in 1925, the monthly average for the first three quarters of the current year declined to 19,000 tons. On the other hand, since the time when this country was obliged to reduce coal exports, and eventually to stop them altogether, certain countries east of Suez, principally India and South Africa, have resumed their shipments of coal through the Canal. From June to the end of September these reached 43,000 tons.

THE maintenance of schools giving technical instruction in watchmaking has long been a practice in both Switzerland and France. The oldest French institution of this sort is a municipal watchmaking school maintained at Besançon since 1861. According to a report by the United States Commercial Attaché in Paris, projects for State support of the watchmaking school have been under discussion for many years. They resulted in an agreement in 1921 between the city and the State by which the school was to be enlarged. Only in June, 1926, however, did this agreement take form in actual construction. The new buildings are to be on ground covering 9300 square metres of a value of 6,500,000f. The new school is to be a national institution. In 1912 there were only 65 pupils attending the school. Now 170 are enrolled and are all that can be accommodated in the space available. The new buildings are planned eventually to house 450 pupils.

THE serious decrease in the consumption of coal in Bombay is pointed out by the Tariff Board in its report on the coal industry. In the four years immediately preceding the war the supplies of coal which reached Bombay amounted to 1,200,000 tons a year. The present average consumption is only 600,000 tons. This is attributable not to any decline in industrial activity, but mainly to the displacement of coal by hydro-electricity and fuel oil. In 1913–14 there were eighty-two cotton mills in Bombay City and Island, all of which used coal as their sole source of power. In 1924–25, sixty-one mills used hydro-electricity as their main source of power, twenty-three used fuel oil, while the number of mills still dependent entirely on coal was seventeen only. The power supplied by the Tata hydro-electric companies in 1924–25 was equivalent to about 400,000 tons of coal, while the imports of oil amounted to 60 million gallons, which may be taken as equivalent to 450,000 tons of coal. The completion of the new hydro-electric stations will lead to a further displacement of coal by electricity.

FOUR pumps intended for the new large power station at Rummelsburg, near Berlin, for conveying pulverised coal to the boiler-house have recently been tested by the Allgemeine Elektrizitäts-Gesselschaft, the makers. Each pump is to convey 50 tons of coal dust per hour from the pulverising plant to the bunkers in the boiler-house, a distance of 250 m. (830ft.) and a height of 35 m. (117ft.) Each pump is driven by a 90-kilowatt motor, running at 960 revolutions per minute, and consists primarily of a long spiral conveyor which propels the coal dust for a certain distance. At the end of the casing air at a pressure of 2 atm. (29·4 lb. per square inch) is blown in, which turns the coal dust into a kind of emulsion, which can be forced through pipes of small bore to a great distance. There is an eight-way slide above the bunkers which can be actuated from a distance by electricity, and with the help of which the attendant at the pumps can deliver the coal dust to any one of the bunkers at will. Electric indicators show to the attendant at the pumps the exact level to which the bunker is filled, and he can therefore single-handed fill all the bunkers from the pump room.

Miscellanea.

THE new plant of the Canada Paper Company at Windsor Mills, Quebec, is the first in Canada to make pulp by the Keebra process.

GERMANY'S commercial fleet, which totalled 5½ millions before the war, sunk to 419,000 tons during the war, and had now been built up to 3,300,000 tons.

POLAND has acquired from French builders five 3000-ton cargo ships, which are to form the nucleus of a mercantile fleet. Three of the vessels have been carrying coal from France and England and two others are on the stocks at Caen. A state trading company is to be formed with headquarters in Danzig.

ARRIVALS of coal by waterway to the port of Hamburg fell short by 16,022 metric tons in the first half of October, compared with the first half of September, and by 8167 tons compared with the second half of September. The falling off was principally due to the strike of quay labourers at the beginning of October.

THE official returns of the Chinese Government Railways show that during 1925 the total revenue was 117,000,000 dollars, while the expenses were 73,000,000 dollars. Both these figures represent an increase on the previous year, but there was a reduction in the surplus of 4,000,000 dollars (1 dollar = 2s. roughly).

IT is reported that a fibre rope that is unsinkable has been produced by an inventor of The Hague. The rope includes a core of "foam rubber," according to the *Journal of Commerce*, that has a specific gravity only one-fourth as great as that of cork, has a practically unlimited crushing strength, and a very great tensile strength.

SHAREHOLDERS of the Marconi International Marine Communication Company, Ltd., have been informed that the company has recently come to a working arrangement with its principal competitor, the Radio Communication Company, whereby substantial reductions in expenditure are effected, together with an improvement in the service to shipowners. The companies retain their separate entity in every way.

LOCHALSH hydro-electric scheme is being proceeded with apace. Recently a Glasgow engineer surveyed some lochs on Balmacara Estate, and another engineer made a survey of others. The report of each is expected to be in the hands of the promoters in a few days, when a general meeting will be held to consider the reports. It is understood that if they are approved, work will be proceeded with forthwith.

THE very successful idea of joint meetings of the Royal Aeronautical Society and the Institution of Automobile Engineers was again carried out on November 4th, when Mr. G. F. Mucklow, M.Sc., read a paper on the effect of altitude and of hydrogen on an internal combustion engine. The value of such meetings of kindred bodies is considerable, and the joint gatherings are, we understand, to be continued by the two bodies in question.

DUBLIN'S first automatic telephone exchange, actually serving about 1600 subscribers, but with a capacity for 4000 lines, will be opened early next year. The exchange situated in Ship-street, formerly formed part of the British military barracks The position has been chosen as being that best able to give relief to the Central Exchange, which has found great difficulty in meeting the increasing demands on its services. Six months later the Merrion Exchange will be completed, and a third, to include all the centre of the city, with Drumcondra and Clontarf will follow.

THE distinguished services in the Chair of Electrical Engineering at University College for forty-two years of Dr. J. A. Fleming are being recognised in signal fashion by the painting of his portrait, the artist being Sir William Orpen. The portrait will be placed in University College, a replica being given to Dr. Fleming himself, who wishes to offer it to the Institution of Electrical Engineers. The Portrait Fund Committee is anxious to bring the fund to a successful conclusion. Any gift, however small, will be acceptable. Subscriptions should be sent to Professor W. C. Clinton, University College, London, W.C. 1.

AMONGST the answers received by the American National Association of Manufacturers in answer to an inquiry concerning the effects of the Ford five-day week, the following note has been received from Mr. George L. Markland, jun., chairman of the board, Philadelphia Gear Works:—"The men of our country are becoming a race of softies and mollycoddles; it is time we stopped it and turned out some regular he-men—too many paternalistic laws by city, State and nation. Any man demanding the forty-hour work week should be ashamed to claim citizenship in this great country. I see in it a gradual sinking into decay."

IT is now reported, states *British Industries*, that the rolling mills in this country will not be producing steel in anything like normal quantities till the end of the year. Arrangements are being made for heavy deliveries of American coal, and a few mills are rolling small quantities of British steel at special prices to meet increased costs. Steel prices are well maintained and likely to be higher, while great caution is being exercised as regards contracting ahead until there is more certainty as to costs. There is still a fair amount of work being offered for both home and export, and if only the strike were out of the way there is a large volume of orders to be placed.

ANOTHER unit was added to the system of the Shawinigan Water and Power Company by the formal opening on October 22nd of the St. Narcisse power station on the Batiscan River, Que. The new station has an installed capacity of 22,000 horse-power, and the power generated is transmitted at 60,000 volts to the Three Rivers, where it feeds into the Shawinigan system. The present development utilises three falls, some of its features being noteworthy in power-house construction. It includes a comparatively low dam above the large fall, the power-house in the gorge near the foot of the rapids below, and a tunnel of 13ft. in diameter, through which the water is carried from the dam to the power-house. The tunnel, which is in solid rock, was driven from four different points, and the work was carried out with such accuracy that the various headings of the tunnel met exactly.

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(For description see page 524)

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THE ENGINEER.

NOVEMBER 12, 1926.

Theoretical and Experimental Elasticity.

Despite the vast amount of mathematical and physical research which, since the days of Galileo, has been concentrated on the study of elasticity and strength in materials, it is a remarkable fact that there is still no approach to unanimity in the views held by different authorities regarding the cause of failure in metals under load. In the course of his Hawksley Lecture last Friday evening, Professor Coker reminded his audience that Rankine many years ago expounded the view that the failure of a metal specimen occurred when the stress applied to it exceeded a certain limit. Unthinkingly we may perhaps be inclined to regard this view as abundantly self-evident and as demonstrated and proved by our everyday experience. But what actual evidence have we in its support? When a load is applied to a specimen the only outward indication ordinarily observed which distinguishes the stressed from the unstressed state is an alteration in the dimensions of the specimen. There are certain other modifications which close observation reveals. A small transitory thermal effect can be detected. If the specimen is transparent its optical properties will be affected. If the load is high enough signs will be revealed that under its influence some rearrangement occurs in the internal structure of the specimen. Carefully analysed, it will be found that none of these indications provides any sound evidence that stress is the deciding factor limiting the load that can be borne by the specimen. When we speak of a specimen breaking under a stress of 28 tons per square inch we are apt naturally to regard the 28 tons as the cause of the breakage. We know that the specimen when unstressed will not break and that when it is stressed to the stated amount it will fracture. But it is purely an assumption to hold that the stress is the real deciding factor. The actual cause *a priori* is just as likely to be some one or other of the various consequences which the application of stress to the specimen produces. We are not entitled to argue that these consequences can only be produced by the application of stress. If they can be produced otherwise, then clearly stress *per se* must cease to be regarded as the prime cause limiting the load which a specimen can bear without breaking.

Many alternatives to the view advanced by Rankine have, as Professor Coker's remarks recall, been advanced. A simple and obvious one is that which holds that a limiting strain is the decisive factor. That opinion was, after considerable reflection, arrived at by St. Venant, an elastician of the highest repute in his own day and still in ours. It is a view which a logical mind, free from the bias of convention and habit and trusting strictly to the direct impressions received by the senses, would arrive at from the phenomena accompanying the breakage of a specimen. The principal phenomenon observed is one purely of strain, and of the subsidiary phenomena strain, and strain alone, may readily be accepted as the explanation. St. Venant's view does not, however, fit all the facts that are now within our knowledge. Both it and Rankine's are upset by, for example, certain aspects of the group of phenomena which we call the fatigue of metals. If we hold to either of these views we are at once committed to a theory as to the nature of fatigue which involves assumptions of a very large order that are either not substantiated or are definitely disproved by experiment. If, for instance, we adhere to Rankine's view we are immediately involved in an attempt to explain how a stress lower than the limiting value can produce locally a stress equal to or greater than that value. If we adhere to St. Venant's view we are forced to contemplate some mechanism leading in an obviously complex manner to the accumulation of strain in a specimen subjected to alternating or repeated loading. Similarly the phenomenon called "creep" obviously does not support Rankine's view. Neither does it support St. Venant's, as a reference to the results of Professor Lea's researches will show. Other elasticians, among them Sir George Darwin, have found the criterion in a limiting value of the shear stress developed in a specimen under load. It certainly seems true that, no matter what may be the nature of the load—tensile, compressive, torsional, bending, and so on—failure involves, or is initiated by, a shear action. That such action is present is deducible from a close study of fractured specimens and is confirmed by mathematical analysis. Shear stress is the only pure stress that can be applied to a specimen, all other kinds, such as bending and simple tension or compression as ordinarily imposed, being of a compound nature. It is therefore logical to extend Rankine's view, provided we hold it, and make the deciding factor a limit of shear stress. In the same way, if we hold St. Venant's opinion, we might make the criterion more definite by specifying a limit of shear strain as the deciding factor. In neither case, however, does the increased definition diminish the difficulties encountered with the less-defined conception. The explanation of the mechanism of fatigue, for instance, becomes more rather than less complex. Other authorities have advanced compound criteria such as a limiting strain combined with a maximum shear stress, or, uniting strain and stress in their dynamic equivalent, have specified as the deciding factor the total energy given to the specimen.

In his lecture before the Institution of Mechanical Engineers, Professor Coker did not attempt in any way to guide us as to the relative merits of these and similar conflicting views regarding the cause of failure in materials. It is certain, however, that had he done so many among his audience would have found greater practical interest in his fascinating, but somewhat scientifically abstruse, account of modern progress in the study of elasticity and plasticity. He would also, we believe, have helped to remove the regret felt by many that after nearly three hundred years of study elasticians are still not in a position to contribute anything but mathematics to our knowledge of the behaviour of metals under load. If at this date they are still unable to tell us what determines the failure of metals, what value, it may be asked, will accrue to us from our somewhat painful endeavours to follow them in the elaborations of their subject. So long as elasticians confined themselves to a purely mathematical discussion of the properties of an idealised imaginary substance, it did not seem to be worth the time of more practical people to seek understanding from them. Within recent years, however, elasticians have exhibited a satisfactory tendency to descend from the clouds of pure hypothesis and to enlist the assistance of experiment. They need no longer be suspected of regarding their subject as one primarily designed to afford an opportunity for the exercise of their mathematical abilities. Modern metallurgical and crystallographic research, the results obtained from the application of X-ray analysis, advances in our knowledge concerning light and the progress made in the investigation of the sub-atomic structure of matter are now all recognised as coming within the purview of the elastician. Photo-elasticity and photo-plasticity—Professor Coker's especial field—the wonderfully beautiful "soap film" method applied by Griffiths and Taylor and others to the elucidation of the distribution of torsional stress

in a specimen of non-circular section and Nadai's study of the behaviour under stress of solid paraffin blocks, are particular instances of the increasing tendency of elasticians to turn at the earliest possible moment in their investigations from mathematics to experiment. If for the time being the elastician's ways still seem hard to follow, if they seem still to be considerably detached from practical questions, if they still appear to neglect elementary considerations in favour of seemingly minor abstractions, we may content ourselves with the knowledge that the basis on which the work is now proceeding is a healthy one, which has been very largely freed from hypothesis and which has been given a definitely experimental foundation. In particular it is desirable to curb any impatience which we may be inclined to show regarding the elasticians' continued failure to come to any settled conclusion regarding elementary matters, such as the true cause determining the breaking of metals. In nothing is it truer than in this instance, that elementary is synonymous with fundamental. There is a vast amount of overburden remaining to be sifted before these fundamental matters can be reached. The answers to what we as practical people may regard as elementary questions will demand a knowledge of elasticity much greater than we possess at present, but towards which, it is certain, we are definitely progressing.

Electrical Distribution.

WHILST considerable thought and ingenuity have been brought to bear on the problem of raising the efficiency of power stations, the equally important and pressing task of modifying and improving distribution systems has to a large extent been neglected. Nevertheless, recent papers and utterances indicate that it is rapidly becoming apparent to those who have set out to better the electricity supplies of this country that if cheap current is to become available the distribution side of the electricity supply business must receive attention. In his paper on "Present and Future Development of Electricity Supply," read before the Engineering Section of the British Association, Sir John Snell drew attention to the importance of minimising distribution expenses which in many cases add very materially to the price at which current is sold. Last week another paper entitled "The Design of City Distribution Systems and the Problem of Standardisation" was read before the Institution of Electrical Engineers by Messrs. J. R. Beard and J. G. N. Haldane, who considered in detail the design of a system that might be adopted as standard, and how far existing systems may gradually be brought into line with it.

That the present is an opportune time for distribution engineers to take stock of the existing position with the object of anticipating the conditions to be met within the course of the next few years there can be no doubt. Improvements in distribution should as far as possible take place in conjunction with the improvements in central stations, for otherwise it is well within the range of possibility that many consumers of electricity will find themselves in little, if any, better position than they were originally. The standard system of distribution which Messrs. Beard and Haldane advocate is the three-phase four-wire system with a pressure of 400 volts between phases and 230 volts between phases and the neutral. Few engineers will object to this recommendation, except perhaps those who have been associated with direct-current distribution all their lives and can see no merit in anything else. As the authors truly remark, at the present time alternating current meets the need of consumers quite as well, if not better, than direct current, except for a very few types of motor drives which can always be dealt with by local conversion and should not be allowed to affect the general decision. The three-phase four-wire system is at least as economical in copper as any other system for giving domestic single-phase supplies at a given voltage to earth, whilst the system is also the most suitable for supplying industrial power. Investigation has shown that, compared with the recommended four-wire three-phase system, the expensive converting plant which direct-current distribution requires increases, under the conditions assumed, the overall distribution costs from 20 to 40 per cent., depending on the load density, even after making full allowance for the saving in labour charges brought about by the modern automatically operated sub-station. As we have often pointed out, there has been far too great a tendency in this country to perpetuate direct-current distribution, which is really a relic of bygone days. From the manufacturers' point of view it is, of course, a very desirable system, involving as it does a considerable amount of costly converting machinery and unnecessary loss. On the distribution side the electricity supply industry of Great Britain is undoubtedly in a very unsatisfactory state. The conglomeration of systems, voltages and periodicities is a great disadvantage which no national system of interconnected super-power stations will remove. Under the standard scheme which the authors advocate there would be only two transformations between the main transmission system and the consumers. In large main sub-stations the transmission pressure would be reduced to 11,000 volts for distribution to large power consumers and to the transforming centres, which would supply the low-voltage networks; in numerous standardised transforming centres the pressure would be stepped down from 11,000 to 400/230 volts for distribution to domestic and small power consumers. We need not, however, consider the authors' scheme in detail. A more complicated and difficult matter is how existing systems can be standardised. As the majority of city areas are already partially developed the complete adoption of the standard system is in most cases impossible. As regards the standardisation of voltage, a very large proportion of the existing systems operate at pressures within the range of 200 and 230 volts, and over this range a change to 230 volts can be carried out at comparatively small expense; indeed, the authors contend that a change over of this sort, including any necessary modifications, to the undertakers' own apparatus, such as sub-station plant meters, &c., ought not to add more than about 5 per cent. to the existing expenditure on distribution, and that on a growing load this would be rapidly offset by the reduced capital expenditure arising from the higher distribution pressure. There are, of course, systems operating below 200 volts, such as 100 and 120 volts. On direct-current systems it would, in these cases, be necessary to replace or re-wind all the motors, whilst on alternating-current systems they might be fed from auto-transformers, which would usually be somewhat cheaper. In any case the cost of the change over might be greater than that involved with the higher voltage systems, but it is to be remembered that the capital expenditure which could be saved in the future would increase with the amount that the voltage was raised. On systems having a normal rate of growth it has been found that the cost of raising the voltage is recovered within, at the most, two years from the time the change was made. With systems operating at pressures between 230 and 250 volts practically the sole advantage which the undertaker is likely to gain from standardisation is the possibility of an increased growth of the load brought about by the benefits which standardisation bestows upon the consumer. Standardisation of voltage is, however, only one step in the direction of the ultimate goal, the next important modification being the general adoption of 50-cycle alternating current, and, needless to say, in direct-current areas where the power load predominates a complete change over would be a very expensive matter. In no case which the authors have considered is it a practicable scheme to scrap the existing system entirely. But in an area where the power load is developing rapidly it pays to superimpose the standard system for dealing with all the new load. That economy is ultimately secured by such a change there appears to be no doubt, although even on a rapidly growing system it may be some years before a saving in dealing with the new load balances the heavy initial cost of the new system. In areas where only a slow growth of power may be expected a complete limitation of the growth of the existing direct-current system cannot be justified. Nevertheless in such areas a great deal can be done in the direction of gradually superimposing a standard system on the most favourable parts of the area as opportunity occurs.

When the power load is small a change over is a comparatively easy matter. Many such changes have taken place during the past few years, a factor which has often had considerable influence in these cases being the reduction in the cost of maintaining old networks when fed with alternating current in place of direct current. There are, of course, various difficulties in the way of introducing the standard distribution system to which we have not alluded, such as that which arises when the system to be standardised does not involve the use of four-core cables, but these difficulties need not be discussed here. The main fact to be emphasised is that in the past far too much money has been squandered on distribution systems, and if in the future cheap electricity is to be made available, every effort must be made to adopt a cheap and efficient system, such as that which Messrs. Beard and Haldane recommend. That all engineers are striving their utmost to simplify their distribution systems we do not believe. There is unquestionably a tendency in this country to extend the uneconomical systems and to install complicated and costly automatic converting plant, rather than to superimpose a relatively cheap and efficient alternating-current system, which sooner or later is bound to show material advantages. To pay attention to the generating side of the electricity supply industry and to neglect the distribution side is a short-sighted policy, for without efficient distribution the long-promised cheap and abundant supply of electricity cannot materialise.

Literature.

Battleships in Action. By H. W. WILSON. Two volumes. London: Sampson Low. 42s. net.

THIS book is in effect a sequel to the author's well-known work, "Ironclads in Action," which appeared in the 'nineties. Although so long an interval has elapsed, the original style of narrative has been followed very closely in the present volumes. Mr. Wilson's method is to give an analytical survey of the naval campaigns that come within his purview, emphasising the technical aspects, and drawing conclusions from such facts as appear to be definitely established. His well-documented pages reveal the thoroughness of his search for material, a great deal of which will be new to the general reader. While the first volume contains a highly instructive *résumé* of naval warfare from the Crimean era to the Balkan conflicts of 1912-13, a more immediate interest necessarily attaches to the second volume, which treats exclusively of the Great War. It constitutes the first critical history of the naval operations of 1914–18, previous versions of which, having been officially inspired by one or other of the late belligerents, are not always free from a suspicion of bias. Mr. Wilson has obviously striven to maintain an impartial attitude throughout. He maintains it so well, indeed, that his comments on British strategy, tactics, and material are not always flattering to national pride. If he has erred at all, it is in trusting a little too implicitly to German sources of information. To this, of course, he might reasonably retort that the German authorities since the war have released more naval data of a technical character than the British Admiralty has seen fit to do. Further, that the accuracy of German statements reflecting on the equipment of our Navy have not only gone unchallenged in this country, but have been confirmed by the writings of Lord Jellicoe and other British commanders. In any case, his criticisms provide food for thought, and will, we hope, be studied by all to whom the efficiency of the British Navy, present and future, is a matter of concern.

From an analysis of the shooting records in the principal engagements, such as Coronel, the Falklands, the Dogger Bank and Jutland, Mr. Wilson is led to conclude that British gunnery in the earlier period of the war showed "a marked and most dangerous inferiority" to the German. In all these actions, he points out, the German ships opened with an accurate and extremely rapid fire, nearly always hitting at the third salvo. Our ships, on the contrary, fired slowly and took longer to find the target. The main facts are indisputable, and no satisfying explanation has so far been offered. The delay in finding the correct range was due, no doubt, to the imperfect instruments in use at that date. Too much dependence appears to have been placed on "spotting," and too little on mechanical appliances for estimating the range and movements of the target ship. Uncertainty on either point would account for the low rate of fire, for when the enemy's position is only to be checked by observing the fall of shot in his vicinity, a considerable pause must necessarily occur between each salvo. The Germans, either because they had better optical equipment, or because they preferred to develop the maximum volume of fire in the hope of scoring a proportion of lucky hits, used to work their guns with the utmost rapidity of which they were capable, discharging a second salvo while the first was still in flight. Judged by the result, these tactics were sound. There is not the least doubt that British guns and mountings could have maintained an equally rapid rate of fire had the target been held. If therefore British gunnery was less effective than the German, the explanation seems to lie in the different methods of fire control, rather than in discrepancy of material. It is common knowledge that each navy followed its own system of calibration, the British preferring a fairly wide dispersion of the projectiles in each salvo, while the Germans tried to achieve a common point of impact. Each system had its merits, but when shooting conditions were good the German method was probably the most effective, the target being hit by three or four shells simultaneously. It was this concentrated fire that proved so disastrous to our battle-cruisers at Jutland. The

Germans possessed a further advantage in the superior quality of their projectiles, which were extremely destructive to moderately armoured ships. Not until after Jutland did the Admiralty adopt an improved type of armour-piercing shell, which, incidentally, more than one of our great munition firms had offered to supply before the war. Again, it cannot be denied that our earlier Dreadnoughts and battle-cruisers were unduly vulnerable to underwater attack, and the latter to gunfire as well. It was a defect that cost us some fine ships, and, what was infinitely more to be deplored, thousands of valuable lives. Mr. Wilson ascribes these shortcomings in the material of the Fleet to the lack of a Naval Staff. That omission has since been made good, and we assume that proper consideration is now paid to all the technical details which count for so much in the sum of fighting power.

That the German Navy was a very efficient fighting instrument is not open to dispute; yet in proportion to its strength it accomplished very little. Fortunately for us, the German naval command failed to take advantage of numerous opportunities for striking blows that would certainly have been dangerous and might have proved disastrous. For this inertia there were several reasons. On the outbreak of war the Kaiser had issued an order forbidding his fleet to take risks. Both the soldiers and the politicians were anxious to keep the High Sea Fleet intact to serve as a pawn in the peace negotiations, and therefore vetoed every important offensive operation that the sailors proposed. Moreover, the whole scheme of strategy which the German naval staff had prepared in anticipation of war with Great Britain was frustrated by an unforeseen development—the test mobilisation of the British Fleet in July, 1914, in place of the usual manœuvres. Even now it is difficult to gauge the full effects of that amazing coincidence, thanks to which the whole of our effective Fleet was practically on a war footing less than a month before hostilities broke out. The possibility of a German surprise attack was thus eliminated. Before ever a shot was fired, we had established command of the Narrow Seas. The German Navy was thrown back on the defensive; the armed cruisers that were to have played havoc with our floating trade could not get to sea, and the High Sea Fleet, upon which such lofty hopes had been built, found itself reduced to impotence. British naval tactics may, as the author suggests, have left something to be desired, but British naval strategy throughout the war was guided by principles which the event proved to be sound.

The account of the Jutland action is concise and informative. It brings out the furious nature of the battle-cruiser duel, the devastating effects of heavy gunfire, and the influence of atmospheric conditions on modern tactics. The ordeal to which Admiral Beatty's flagship, the Lion, was subjected is vividly portrayed. "The state of the ship during and after the battle was indescribable. The sheets of water which came on board when the German salvoes dropped close to her, the streams pouring from the fire hoses, and the inrush from the sea through her injuries, left her decks awash, so that the wounded could not be placed on them without grave risk of their being drowned. Everywhere were fires, dense choking smoke, steel splinters and torn plates with edges so sharp that they cut like razors. The impact of the heavy German projectiles made the very structure tremble as though it had been struck by gigantic sledge hammers." There were moments when it seemed to onlookers as if the Lion, the Malaya, and other great ships were about to share the terrible fate of the Queen Mary. Many German ships also were in imminent peril of blowing up when the flash of bursting shell ignited ammunition and flames roared up to the masthead. In view of the German Fleet's hairbreadth escape from annihilation, its subsequent passivity, and the demoralisation of its *personnel* which culminated in mass mutiny, the author's dictum that Jutland, although no triumph for the Germans, was "a success on points for their arms," will not command general assent. As a record of sea warfare during the past seventy years, and of the development of ships, weapons, and tactics in this period, Mr. Wilson's volumes are of the utmost value. Because of their detailed treatment of technical questions which the conventional histories ignore, they will be welcomed by naval officers and others who have a professional interest in the material elements of naval warfare.

Moveable Bridges. Vol. I., Superstructure. By O. E. Hovey, M. Am. Soc. C.E. London: Chapman and Hall, Ltd. 1926. Price 30s.

In this book, the term "moveable bridge" means the opening span of a bridge or an individual structure consisting of one or more opening spans. Descriptions of such works are often included in papers and articles relating to dock, harbour and bridge works, or are separately presented with the object of furnishing precise information as to their form and details; but, as a subject in itself, the opening bridge has not received much attention. Mr. Hovey has collected and arranged a considerable amount of scattered data, in order "to put the results of original investigations and the lessons learned from long experience before fellow-engineers, in the hope of rendering a real service to the profession." His book has, however, a much wider scope. Its practical value is the greater for the restraint shown by the author in restricting consideration of rarely used types to his attractive historical introduction and the chapter on "types," which concludes with a bibliography relating to those which are seldom used, that is, the four groups, Bélidor bascules, retractile, transporter, and pontoon bridges. In this chapter those and the other types are described in general terms; some broad principles affecting the choice of a type are briefly stated; while swing, bascule, and vertical lift bridges are discussed with due consideration of conditions of site, water traffic and land traffic. The inherent qualities, structural, operative and economical, of each type are also discussed.

The author then proceeds with the separate consideration of each of these three types, furnishing examples of important and interesting works, but refraining from overloading these chapters with such material, in order that he may adequately present the general data. In Chapter III. he compares centre bearings with rim bearings, gives examples of typical spans with tables of reactions and weights, and curves of total weights to spans for railway and for highway bridges. The chapter on bascule bridges opens with a series of descriptions of works, including Vescovalis' Tiber bridge, the Tower Bridge, fully illustrated, and a number of American bridges. The several forms—Scherzer, Rall, Strauss, Brown, and Abt—are discussed with well-illustrated examples. Vertical lift bridges receive similar treatment, beginning with Hood's Surrey Canal bridge, and including, with the illustrations, twelve pages devoted to Waddell lift bridges.

If this book were like some that seem to be regarded as satisfactory works, it might end here and be classed as useful, but, like the dump wagon in the advertisement, it is "different and better." The author has got only half-way, having reserved the remainder of his 350 pages in order to deal with the elements of the subject; continuous spans; analysis of swing bridges, including a study of the partially continuous beam; the analysis of bascule and vertical lift bridges; the separate consideration of beams, trusses and frames; and about fifty pages of details of design.

All this matter is illustrated by appropriate diagrams and furnished with tables of data.

The author, who is assistant chief engineer of the American Bridge Company and a member of the American Society for Testing Materials, writes as one fully conversant with both the elementary and the executive aspects of his subject. Even as a work of reference his book has some value, but its more important field of usefulness is that of direct application to bridging problems and to design. It is, moreover, a work which may be commended to civil engineers and students as a very readable treatise which presents the subject as a whole, and is worth study, apart from its direct value as an aid to the solution of a problem or the preparation of a design.

SHORT NOTICE.

The Lightning Graphs. By I. S. Dalgleish. London: Crosby Lockwood and Son. Price 5s. net.—This book should be of considerable use to engineers, physicists, surveyors, and others in dealing with calculations which involve certain formulæ the form of which does not lend itself to straight manipulation on a slide rule. The graphs are in the form of nomographs and cover the equations (1) $a^2 = b^2 + c^2$, (2) $a^n = d$, (3) $\sqrt[n]{a} = d$, (4) $v = e^r$, (5) $w = e^{-r}$. We have tested the graphs and find them easy to use and sufficiently accurate in their results for most purposes for which the accuracy given by a slide rule does not require to be exceeded. The range of variables covered by the graphs is restricted to certain limits in some instances, but should those limits have to be exceeded a modified use of the graphs enables the calculation to be completed. In addition to their direct use, the graphs by simple means enable the common and hyperbolic logarithms of numbers and the reciprocals of numbers to be read off with very little trouble. Similar nomographs for other frequently occurring equations are, we understand, in preparation.

Transport Aviation. By Archibald Black. New York and London: Simmons-Boardman Publishing Company. Price 12s. 6d. net.—This volume is, we take it, designed to assist those who may be contemplating the establishment of a commercial air transport service. It provides a record of what has been already accomplished in this direction and gives information regarding commercial factors based on the experience of existing operating companies and organisations. On the strictly technical side the volume has few outstanding merits. The design of commercial aeroplanes is dealt with cursorily and most of the remarks which the author has to make on this subject are either trifling or obvious. On the commercial side the author analyses the position in great detail. He culminates his studies in an attempt to evolve a standard organisation for the *personnel* of commercial aeroplane services. The success of his efforts may be judged from the fact that he manages to find positions for 230 different people in a hypothetical service employing only eight regular pilots and operating only one aeroplane each way per day. The book is American in its origin and production, and is not likely to meet any outstanding need in this country.

The Discoverer of Gas Lighting. By Walter T. Layton, F.R. Hist. Soc. With a Foreword by Dr. Charles Carpenter, President of the South Metropolitan Gas Company. London: Walter King, Ltd., Office of the *Gas Journal*. 1926. Price 2s.—It is well known that Murdock's experiments on the production of coal gas were anticipated in some measure by a Rev. John Clayton, of Crofton, near Wakefield. His note on the "Spirit of Coal," which appeared in the "Philosophical Transactions" of 1739–1740, records an experiment which puts that fact beyond doubt; but so far little has been known about Clayton himself, and Mr. Walter Layton has done a real service to technological history in the close inquiry he has made into the Clayton family. Of equal interest is the fact that he has succeeded in establishing a fairly certain date for Clayton's discovery of the properties of coal gas. In 1693 Clayton wrote a paper on Virginia, and presumably because that appeared to be an unlikely field in which to search, a paragraph which occurs in it and which enabled Mr. Layton to arrive at a date with some approximation has hitherto been overlooked. This paragraph makes it quite clear that the experiment was carried out before 1688, and as Clayton had visited Virginia two years earlier, it is not unlikely that it took place some time before 1686. Mr. Layton reaches the conclusion that a likely date would be 1684. The date 1664, which has hitherto been accepted, is shown to be absurd, as Clayton was only seven years of age at that time. The little volume is an addition of unquestionable merit to the history of gas lighting.

Reminiscences of an Old Engineer. By A. J. G. Brisbane, 1926.—Civil engineers all over the world, and particularly those in Australia, will find a great deal to interest them, much to instruct them, and not a little to amuse them in the reminiscences which Mr. A. J. Goldsmith, M. Inst. C.E., has collected together in this little pamphlet. Mr. Goldsmith was born in London in 1848, and has now retired from active participation in the profession which he followed for a great many years. He is especially known in conjunction with dredging undertakings, and for something like forty-five years was associated with the famous contracting firm known at one time as John Walker and Co., but more recently as Walkers Ltd. In this short history of an eventful life there will be found personal records of events which are now only remembered by the older engineers. It is they who will enjoy most Mr. Goldsmith's stories, for they will revive almost forgotten memories of events which stirred the engineering world twenty, thirty, forty, and even fifty years ago.

Aluminium Foundry Work. Published by the British Aluminium Company, Ltd. 1926.—Although this is a trade publication, in the sense that it is published by a manufacturing company, and is presented to responsible persons, it fully deserves to be classified amongst the engineer's library books. It is, of course, thoroughly practical in nature, as it is essentially intended for the use of aluminium foundry foremen and managers. It bristles with hints and instructions about the casting of aluminium which the foreman who is not familiar with that metal and its alloys could hardly be expected to know. We have little doubt that it has already been circulated widely to such men, but if there are any who have not received copies, we can assure them that they will do well to make application for it. There is little or no advertisement in the book, and the facts given are all of general and not particular application.

BOOKS RECEIVED.

Regelung und Ausgleich in Dampfanlagen. By Th. Stein. Berlin: Julius Springer, Linkstrasse, W. 9.

Field Astronomy. By D. Clark. London: Constable and Co., Ltd., 10–12, Orange-street, W.C. 2. Price 10s. 6d. net.

Electricity Supply, 1924–1925. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 15s. net.

The Motor Electrical Manual. Third edition. London: The Temple Press, Ltd., 7–15, Rosebery-avenue, E.C. 1. Price 2s. 6d. net.

Stability and Seaworthiness of Ships. By T. B. Abel. London: Hodder and Stoughton, Ltd., Warwick-square, E.C. 4. Price 18s. net.

Instructions as to the Survey of Life-saving Appliances. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 1s. net.

Metal Work. Second edition. By H. M. Adam and J. H. Evans. London: Edward Arnold and Co., 41, Maddox-street, W. Price 6s. 6d. net.

Chemistry of the Oil Industries. Second edition. By J. E. Southcombe. London: Constable and Co., Ltd., 10–12, Orange-street, W.C. 2. Price 12s. 6d. net.

Solving Sewage Problems. By G. W. Fuller and J. R. McClintock. London: The McGraw-Hill Publishing Company, Ltd., 6, Bouverie-street, E.C. 4. Price 30s. net.

Civil Engineering Specifications and Quantities. By C. G. Coleman and G. M. Flood. London: Longmans, Green and Co., Ltd., 39, Paternoster-row, E.C. 4. Price 10s. 6d. net.

Minutes of Proceedings of the Institution of Civil Engineers. Vol. 221. Edited by H. H. Jeffcott. London: The Institution of Civil Engineers, Great George street, S.W. 1.

Engineering Problems. By W. G. Raymond, S. M. Woodward and I. H. Prageman. London: The McGraw Hill Publishing Company, Ltd., 6, Bouverie-street, E.C. 4. Price 5s. net.

Union des Ingénieurs sortis des Ecoles Spéciales de Louvain. 53me Année, 2me Bulletin Technique, Octobre, 1926. Brussels: Etablissements J. Schicks, Rue du Marché du Parc, 28.

Report on the Economic and Financial Conditions in Germany, 1925–6. By J. W. F. Thelnall, M.C. London: His Majesty's Stationery Office, Adastral House, Kingsway, W.C. 2. Price 4s. 6d. net.

Arctic and Western Hudson Bay Drainage for the Climatic Year 1923–24. Being Water Resources Paper No. 46 of the Dominion Water Power and Reclamation Service of the Canadian Department of the Interior. Ottawa: F. A. Acland, Printer to the King. 1926.

A 600 B.H.P. Heavy-Oil Engine.

On Monday last, November 8th, we attended demonstration trials of a new type of vertical four-stroke cycle, single-acting heavy-oil engine which has been designed by Belliss and Morcom, Ltd., of Ledsam-street Works, Birmingham, for industrial and marine auxiliary use. The six-cylinder unit which we illustrate in the present article has been built for the Shrewsbury Corporation electricity works and will shortly be installed in that power station. As shown by Fig. 1, the set comprises a six-cylinder Diesel engine coupled direct to a 400-kilowatt, 460-volt generator supplied by the Rees-Roturbo Manufacturing Company, Ltd., of Wolverhampton. The general particulars of the engine are given in the following table, the fuel consumptions and performance figures being taken from a series of official trials which were run last week at the engine builders' works for Mr. C. M. Johnston, the manager and engineer of the Shrewsbury Corporation Electricity Department.

Engine Particulars.

Designed engine output	600 B.H.P.
Number of cylinders	Six
Diameter of cylinders	15·5in.
Piston stroke	17in.
Normal running speed	350 r.p.m.
Mean indicated pressure	93 lb./sq. in.
Mechanical efficiency	74 per cent.
Fuel consumption per kilowatt-hour	0·61 lb.
Fuel consumption per B.H.P.-hour	0·41 lb.

The trials in which these figures were obtained were run on Anglo-American Diesel oil having a specific gravity of 0·8 to 0·9. When we inspected the engine on Monday last the engine was again running on full load, and we found it free from noise and vibration. The tachograph records showed an even turning moment, which was stated by the makers to be generally comparable with similar diagrams taken from their steam engine-driven electric generator sets.

The New Design.—In getting out this new type of high-efficiency heavy-oil engine the makers have—so they inform us—taken full advantage of their experience in building both open type and submarine oil engines, and in reconditioning and adapting several ex-enemy submarine motors for electric generating work. In the new unit it has been sought to retain a simple and robust design and at the same time to cut down all superfluous weight. The total weight of the engine with all its necessary accessories is, we are informed, about 40 tons, which corresponds to nearly 150 lb. per brake horse-power. From the sectional drawings we reproduce in Fig. 2 the general sturdiness of the bed-plate, crank case, cylinder jacket, and cover castings can be noted, these parts all being made in special selected cast iron, the requisite stress-resisting characteristics being obtained—in the case of the bed-plate and crank chamber—by the introduction of suitably designed transverse webs and ribs. We noted in particular that the distance between the centres of the cylinders has been reduced to a minimum without the sacrificing of necessary bearing length. It amounts, as may be gathered from the drawing, to about 1·7 times the diameter of the cylinder. At the fly-wheel end of the engine—see Fig. 2—it has been found possible so to increase the length of the bearings on either side of the skew gear wheel on the crank shaft that the usual outboard bearing is dispensed with and a correspondingly shorter overall engine length obtained. As regards cylinder output, we are given to understand that by devoting special attention to the effective cooling of exhaust valves, cylinder covers, pistons, and liners, it has been found possible to increase the output per cylinder by about 25 per cent. compared with that of the same size in an open type engine of earlier design.

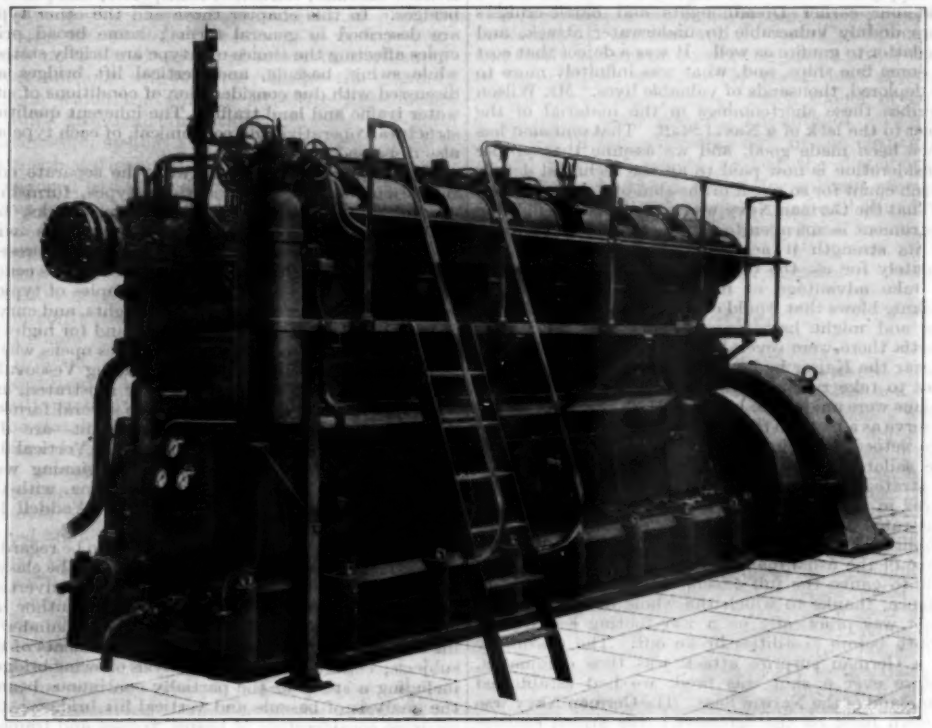


FIG. 1—600 B.H.P. OIL ENGINE AND GENERATOR

Main Scantlings and Running Parts.—The bed-plate is of the ordinary box pattern and is arranged to carry the crank shaft bearings. Arrangements are provided to collect within it all the waste lubricating oil, which is then drained into a sheet metal sump external to the engine. The crank case is bolted to the machined top of the bed-plate and it is furnished with inspection doors giving good access to the moving parts. The working forces of the cylinders are taken by the transverse ribs already referred to, which are illustrated in the left-hand section of drawing Fig. 2. On the top of the crank case are bolted the cast iron cylinder casings, into which the liners are pressed. Spiral ribs are cast within each casing with the object of securing more effective cooling of the liner surfaces. The cylinder casings also carry projecting brackets on which the cast iron trough enclosing the cam shaft is supported. The details of the crank shaft, connecting-rod, piston, and running gear are clearly shown in the right-hand view of drawing Fig. 2. A one-piece crankshaft is employed with webs slotted from the solid forging. The connecting-rod is also a steel forging and it is furnished with marine type top and bottom ends having white metal-lined steel bearing shells. The crank shaft and connecting-rods are drilled for forced lubrication, the oil being supplied under a pressure of about 10 lb. to 15 lb. per square inch from a common rail fixed inside the crank chamber. The piston is made with a removable head, which is oil cooled on the labyrinth principle, the cooling oil being supplied to and taken from the piston through the swinging links illustrated in Fig. 2. Another common rail which runs along

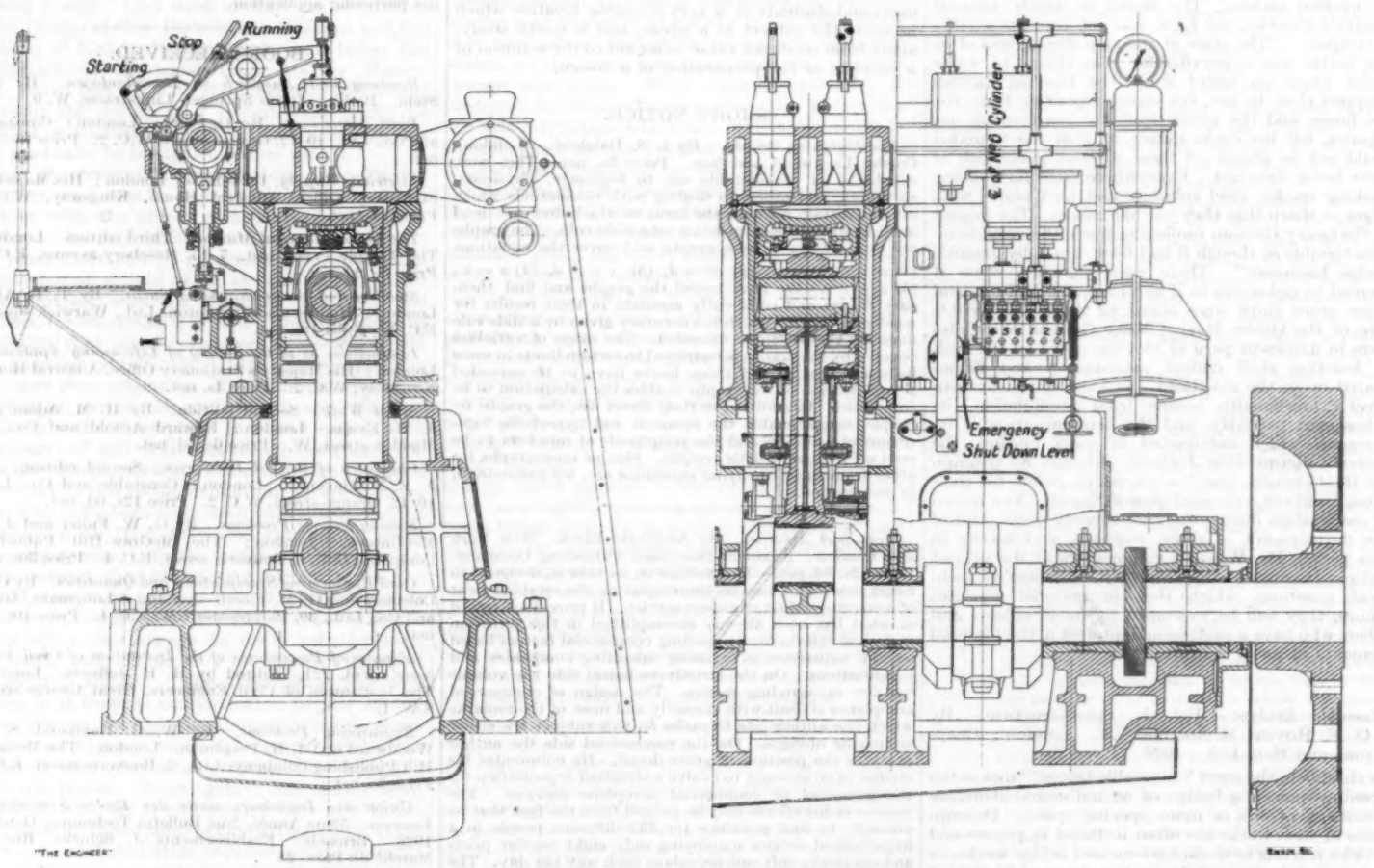


FIG. 2—600 B.H.P. HEAVY-OIL ENGINE—SECTIONS

the other side of the crank case supplies the piston cooling oil at a pressure of about 25 lb. per square inch. All the oil outlets are fitted with separate tundishes, so that the attendant can note the temperature of the cooling oil discharged from each piston.

Cylinder Covers and Valves.—Drawing Fig. 3 serves to show the arrangement of valves in the cylinder cover. Each cover has an air inlet, an exhaust and fuel valve, whilst air starting valves are provided on three of the six cylinders. The various valves are placed off centre, as shown in Fig. 3, so that a free flow of cooling water between the valve pockets is made possible. In the case of the fuel valve a thin steel tube forms the valve pocket, thus giving a larger flow of water in the narrow space between the air inlet and exhaust valves. The cooling water arrangements with three cooling water pipes discharging on the face of the cover are clearly shown in the lower part of Fig. 3. It will also be seen from the upper part of this drawing that both the exhaust valve itself and also its casing are water cooled, the connections to the distributing main and discharge pipes being made at the top of the valve by means of flexible tubing. The air inlet valves are connected to an air inlet silencer fitted vertically on each cylinder cover; at the ends of the crank case two connections are made at the base of two of these slotted metal silencers to the crank chamber space so that it is kept ventilated. A one-piece fuel valve is fitted and the upper part of the valve casing carries a fuel test cock and also a relief valve. The valve operating levers are carried on an excentrically mounted fulcrum spindle above the cylinder covers, rollers being fitted which engage with the cams

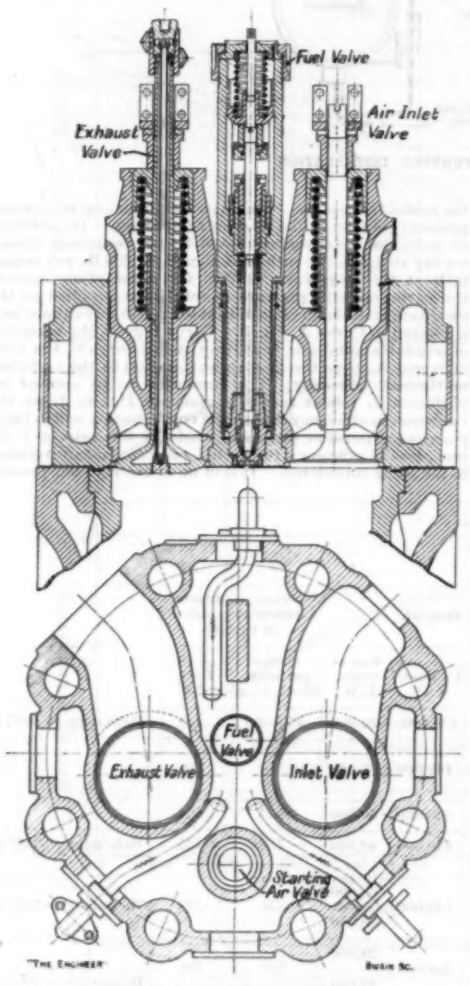


FIG. 3—CYLINDER COVER

on the shaft, which runs the whole length of the engine at approximately cylinder cover height. The starting and running controls, which are operated from the top platform at mid-engine position—see Fig. 1—are so interlocked with the fuel pump controls—see Fig. 2—that no fuel can enter the working cylinders while they are being run on air during the starting period. All cam shaft and roller bearings are fitted for forced lubrication, and any waste oil is collected and returned to the oil sump. This arrangement gives very clean and silent running valve gear.

Fuel Pump and Injection Air Compressor.—The fuel pump shown in Fig. 2 and in cross section in Fig. 4 is placed at the fly-wheel end of the engine. The pump plungers are arranged in two groups of three and the two pump crossheads are driven by excentrics mounted on the cam shaft. A shaft type of governor designed for close speed regulation is fitted, with the usual lever attachment to the fuel pump. A useful feature of the pump design is the arrangement of all the adjustable parts and controls on the outside of the pump. The pump body is machined from a steel block, and besides being fitted with the usual suction and delivery valves each pump is provided with a hand priming arrangement. On the left-hand side of the pump an emergency shut-down lever is arranged. It can be operated from the floor level and cuts off the supply of fuel from all cylinders. The air compressor which supplies the injection and starting air is mounted at the end of the engine and is driven from an extension of the crank shaft. It is of the Belliss standard three-stage design and silent disc valves are fitted. Provision is made for cooling the air after each stage of compression and also after the high-pressure stage. For this purpose vertical multi-tubular inter and after coolers are employed, which are so grouped around the compressor cylinders that there is only a very small number of heated pipes and surfaces. The air injection receiver or blast bottle is mounted at the end of the raised platform and the starting receivers are arranged separately. During the time of our visit the engine continued to run on full load with a blast pressure of about 900 lb. per square inch.

Lubricating Pump and Filter.—A lubricating pump of the gear type is arranged at the compressor end of the engine, and in communication with it is an Auto-Klean filter. A special oil cooler is provided and pressure gauges are fitted to show the pressure of oil delivered to the common rails for the main bearing and crosshead lubrication and piston cooling. There is a separate gauge which shows the pressure of oil before the filter, and this enables the attendant to note when the filter requires cleaning, which is simply done by turning the filter handle which moves the interleaved filter plates. At the time of our visit the pump was delivering oil to the bearings at 15 lb. per square inch, cooling oil to the pistons at 28 lb., and the pressure before the filter was about 17 lb.

Starting and Running Controls.—We have already briefly referred to the starting controls, which are arranged at mid-engine position on the upper working platform. For

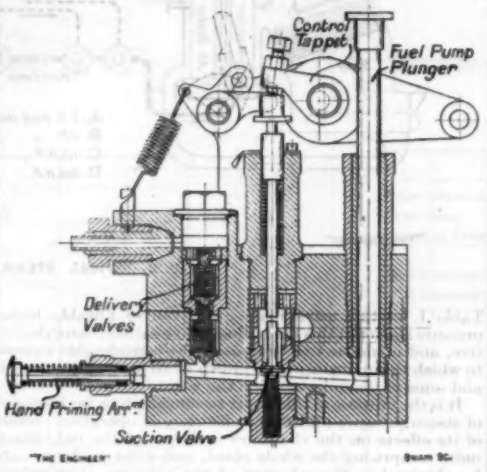


FIG. 4—FUEL PUMP—SECTION

convenience the gauge board, with the compressor and intercooler gauges, is placed at the left-hand end of the platform in full view of the attendant. The valves on the starting receivers only admit starting air to the master valve and distributing box which is fixed at the end of the main cam shaft near to the air compressor. A special cam operates three distributing valves, which are radially disposed at an angle of 120 deg. to each other and correspond to the starting positions for the three cylinders on which air starting valves are fitted. Normally these three valves are held clear of their seats by springs, but when compressed air is admitted from the receiver they are forced on to their seats and are operated in correct sequence by the cam referred to, which admit air through the automatic starting valves to three cylinders. The engine was run up in our presence and started with ease, and the emergency shut-off control was also tested. In conclusion, we may refer to the neat arrangement of water-cooled exhaust manifold, which is arranged to take the cooling water discharged from all parts of the engine. During our visit a multiple-point pyrometer attachment was fitted to the engine and under full-load rating the average exhaust gas temperature at the exit from the cylinders was shown to be about 737 deg. Fah., with a plus or minus difference between cylinders of not more than, say, 40 deg. Further tests are to be run when the engine is erected on site.

High Pressure Steam.

THERE was a very large attendance of members and visitors at the meeting of the North-Western Branch of the Institution of Mechanical Engineers, at the Engineers' Club, Manchester, on Thursday, the 4th inst., to hear Mr. H. L. Guy read a paper on "The Economic Value of Increased Steam Pressures," re-publication of which we begin on page 534 of this issue. Mr. C. Bentham presided. The author handled his subject in a very lucid manner, and by the aid of a number of lantern slides of diagrams, demonstrated the various factors which entered into this highly technical subject. Plants for utilising steam up to a pressure of 700 lb. per square inch were dealt with, and Mr. Guy having summarised the *pros* aand *cons* came to the conclusion that probably 350 lb. would represent the maximum economic pressure, taking everything into account, in this country.

An interesting discussion followed the reading of the paper, in spite of the disadvantage that the paper had not been printed and circulated. The chairman, in proposing a vote of thanks, said they had had a great treat. The paper had been presented in a masterly manner, and the chief point in it was its extreme practical value. The vote of thanks was supported by Mr. Daniel Adamson.

Mr. A. M. Ranft said Mr. Guy had shown them the value of the hot side of steam, but had not shown the value of the low temperature side. It was commonly known that one of the greatest troubles of turbine designers was how to utilise all the energy in the steam to the best advantage, and they were always taking ways and means of reducing losses. Mr. A. Saxon said that the paper would help to dispel the idea that the steam age was passing. They were bound to look to steam as the prime power available in a country like this for general electrification schemes. Mr. W. S. Burge, in the course of a lengthy contribution to the discussion, said he had come to the conclusion that pressures of 600 lb. to 700 lb. per square inch were justified. After 650 lb. Mr. Guy's curves showed that the gain dropped very rapidly. With regard to regenerative feed heating, Mr. Burge thought the author had possibly overlooked the fact that where regenerative feed heating was considered in conjunction with economisers, it was almost the universal practice to assume that the feed heat was attained before the condensate entered the economiser. He failed to see any reason why this was necessary. There was no real difficulty in providing feed heating into the economiser up to some quite moderate temperature, say, 150 deg. Fah. He considered that the combination of an economiser and air reheater was generally the best. He then went on to recite some of the results obtained in American power stations where reheating was included in the reduction of heat consumption over variable loads. At the Columbia Power Station 1 kilowatt-hour was being obtained for an expenditure of 12,800 B.Th.U.

Mr. G. Arrowsmith, speaking on the wetness curve, which the author had taken throughout his investigations, *i.e.*, the curve based on a theoretical wetness of the steam at different stages, agreed that in many cases it gave remarkably accurate results, but he was doubtful about it when one got very far down the wetness area. Actually there must be some form of supersaturation occurring, and supersaturation was based on a time factor. The time of expansion in the small turbine was less than that in the longer machines.

Dr. T. B. Morley expressed his interest in the thermodynamic side of the paper. The cycle of operations described was approaching the theoretically perfect or Carnot cycle. There had been a great deal of study of the use of high pressures, of resuperheating and of regenerative feed heating, and most of the published work had come from America. It was much to their advantage to have a paper containing the results of carefully made calculations.

Mr. J. M. Newton pointed out that Mr. Guy had been forced to make numerous assumptions, and the value of his conclusions depended upon the accuracy with which those assumptions corresponded with the facts. Mr. Newton thought they corresponded very closely with common practice. It was interesting to note that the first notable advance in high pressures took place in this country. America had passed us temporarily, he hoped, and in a few years we should have details of the working results of the American stations to compare with those obtained from Barton and Barking.

Mr. Guy, in the course of his reply, referred to Mr. Burge's remarks on American practice. He said, putting cost out of the question, there was a justification for pressures of 650 lb. and 750 lb. per square inch, but unfortunately for engineers cost was the most important consideration. In his paper he had been concerned only with the effect of a single variable, namely, the effect of pressure, and he thought he had shown that the effect of reheating on his particular inquiry was negligible. The suggestion that feed heating by bleeding steam from the turbine could be used to carry the temperature of water above that used in the economiser was interesting, but that method involved "packing off" the steam before it reached the turbine. There was a field for investigation of the subject. The best average result of American stations that he knew was not obtained in the 600 lb. pressure stations, but in the station where the pressure was 350 lb. He did not think that the speed at which the steam passed through the turbine was as important as Mr. Arrowsmith suggested. It was quite possible from the point of view which he adopted that the proper pressure for adoption would vary in different countries. It depended on the ratio of increased cost. It should be recalled that the conception of reheating had originated with a Manchester engineer.

MACHINERY AND PROFIT AND LOSS.

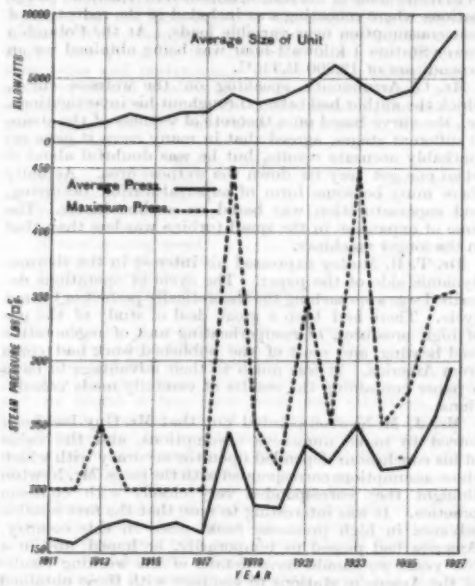
THE necessity for the scientific measurement of profit and loss was indicated in a paper by Mr. P. D. Leake, delivered to Manchester accountants this week. The proposal to set up a State-aided electricity supply industry was taken as a text. Mr. Leake pointed out that as matters now stood, no adequate provision had been made to ensure that the book values of the vast electrical plants which it was proposed to erect should be kept parallel with the going-concern values of those plants actually existing from time to time. All classes of electrical plant, he said, represented wasting assets of a type peculiarly liable to become obsolete as a result of the rapid development of electrical science and technique. As a result, he continued, such undertakings were constantly faced with the necessity of replacing obsolete though otherwise perfectly good assets by the installation of more up-to-date plant. Municipal authorities, similarly, were embarking, to an increasing extent, upon undertakings described as "reproductive," which involved the outlay of large sums of public money in the erection of plant and machinery. The profit reported to arise from such undertakings was not at present measured as it should be on an exact basis, and thus the word "profit" had no precise meaning, and the true financial position of such undertakings was often unknown. Without much difficulty the computation of annual profit and loss might be raised to an exact science, but progress in this direction was handicapped by precedent and ancient custom. Mr. Leake indicated what he considered were the two most difficult factors involved, the first being the exact character of the expenditure, including expired capital outlay and loan interest, which must be charged against revenue, and the second the proper method of measuring the amount of expired capital outlay on industrial plant.

As a result of the closing of Finsbury Technical College, the Meldola Library and the Chemical Library of the College have been presented to the Institute of Chemistry, and have been placed in a room adjoining the library of that Institute. The Streatfield Memorial Fund has also been transferred to the Institute, and arrangements have been made for the delivery of the ninth annual Streatfield Memorial Lecture by Mr. F. C. Robinson on "The Chemist in the Non-ferrous Metallurgical Refinery," at the Institute on Friday, November 19th, at 8 p.m.

The Economic Value of Increased Steam Pressure.*

By H. L. GUY.

In the pursuit of increased efficiency of steam power plant in the last decade, both the range of steam conditions with which it operates has been increased and the character of the cycle employed has been modified. The success attending these developments, coupled with the increase in size of plant involved and the greater skill with which it is operated, is illustrated by the fact that in the last ten years the thermal efficiency of the best power stations has been improved by some 50 per cent.



Progress in Steam Pressure adopted for Steam Turbines for Power Stations.
"The Engineer" Swain Sc.

FIG. 1—STEAM PRESSURES AND UNIT SIZES

Under the first class of changes steam pressures have been materially increased, steam temperatures have shown some advance, and, in general, the vacua obtained with given water temperatures have been increased. Of these, the change in steam pressure is perhaps the most striking and profound, and further, whereas the maximum steam temperature has in recent time shown a tendency to become stationary, and vacua with given water temperatures, if anything appear to be slightly reducing, the position as regards steam pressure is still in a state of flux. The steam cycle itself has changed as the result of the general adoption of regenerative feed heating by the extraction of steam from the turbine at successive points in its expansion, and also in some cases by taking the steam out of the turbine after partial expansion and resuperheating before returning it for expansion to be completed. The advantage to be derived from both these operations is a function of the initial steam pressure.

The way in which the average steam pressure adopted has changed with time, is shown in Fig. 1, based on the orders received by the firm with which the author is associated. The maximum pressure for which plant was ordered is also plotted. The first considerable peak shown is of historical significance, representing, as it does, the first commercial installation employing a considerably increased steam pressure, multiple stage turbine or "Regenerative" feed heating and resuperheating. Fig. 1 also shows the average economic output of sets ordered each year, because there is, and should be, a direct connection between this and the average pressure curve. In Table I. certain particulars are given of notable high-pressure stations; this list is illustrative rather than exhaustive, and is inserted to emphasise the considerable extent to which this movement has grown in all parts of the world and some of the milestones on the way.

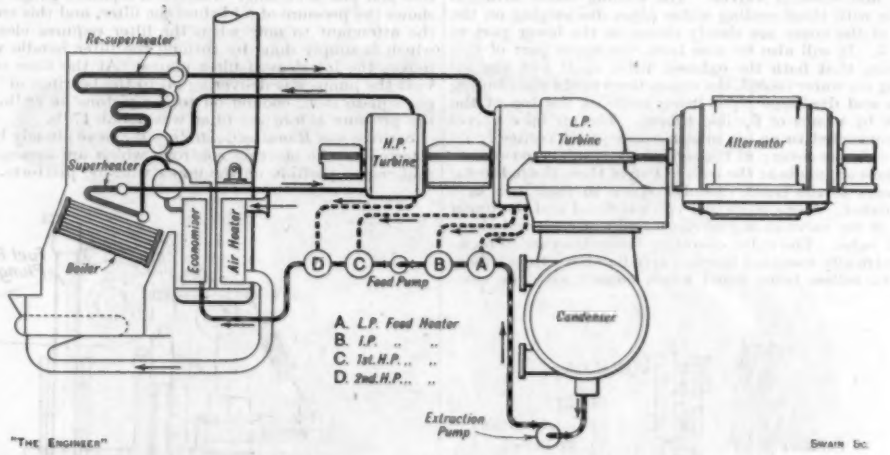


FIG. 2—TYPICAL STEAM TURBINE INSTALLATION

It is the purpose of this paper to consider how far increase of steam pressure affects the efficiency of operation; some of its effects on the character and cost of the individual units comprising the whole plant, and what guidance can be obtained in the selection of the pressure appropriate to any particular case. Fig. 2 illustrates diagrammatically the type of complete installation considered, consisting of a steam turbine arranged for resuperheating, several stages of regenerative feed heating, and boilers equipped with economisers and air preheaters. While we are concerned throughout with the influence of a single variable—initial steam pressure—upon the economics of a power station, we shall find it necessary to investigate the way in which each feature just enumerated separately, affects the efficiency of the whole.

Let us therefore first consider the gains to be expected from the adoption of increased pressures in a simple condensing turbine installation. For this purpose steam will be assumed to be supplied to the turbine stop valve at a normal total temperature of 700 deg. Fah. In commercial operation the possibility of the total temperature being frequently 50 deg. Fah. above the normal is a probability, so that such plant must be suitable for a maximum total temperature of 750 deg. Fah. While constant total temperature with varying pressure has been taken, a plant can be made to operate at moderate pressure at a given total temperature rather more safely than one at high pressure, because, in general, as pressures increase, the maximum stresses in certain parts tend to increase. There is no rational excuse for adopting as a basis the alternative course of maintaining the superheat constant and imagining the total temperature to increase with pressure. A vacuum of 29in. Hg. with 30in. barometer has also been adopted. The effect of variations from these conditions will be considered later.

Calculations throughout are based on Callendar's enlarged steam tables; extrapolation, where necessary, was made by the use of the formulæ employed in building up the tables themselves. Steam at 200 lb. per sq. in. (gauge) pressure is taken as the basis of comparison. In addition, an individual stage efficiency of 80 per cent. was chosen for dry steam in the turbine designed for 200 lb. per square inch at the stop valve. With the assumptions stated, the variation with pressure in total heat supplied to the steam expressed as a ratio of that for 200 lb. per square inch is plotted in Curve A, Fig. 3. Curve B gives the variation of available adiabatic heat drop; while curve C, the ratio of B and A, gives the first approximation to the variation in thermal efficiency. The correction to be applied for variation in reheat factor is given in D. E shows the variation in efficiency due to the condensation which takes place as expansion proceeds, made at the rate of 1 per cent. loss in efficiency for each 1 per cent. mean wetness in the stage considered. It is of no moment to our present discussion to debate whether this loss can be rightly ascribed to "wetness" or to the effects of "supersaturation." The ascertained fact is that, no matter the reason, whether as a result of increased friction or decreased available heat, the loss in a straight condensing turbine closely approximates to the value stated.

The net result of combining these two corrections D and E with C is shown in curve F. Curve G has been obtained from curve F by making a correction for the remaining turbine losses affected by pressure at the rate of 1 per cent. increased loss for each time the pressure is doubled. This relatively small rate is obtainable only in plant of reasonable size for the speed at which it operates;

TABLE I.—*Recent Progress in Steam Conditions for Super-power Stations.*

Item.	Reference.	Started up.	Customer.	Power station.	Output. Initial K.W.	Output. Ultimate K.W.	Size of units, K.W.	Steam conditions before stop valve or turbine. Gauge pressure, lb./sq. in. g.	Steam conditions before stop valve or turbine. Temp. ° F.	Remarks.
1	*Engg.*, 13/6/24, 11/7/24	1920	Newcastle E.S. Co.	North Tees	60,000	100,000	20,000	450–500	650	Reheating to 500° F.
2	Inst. Civ. Engrs., Vol. 218, No. 2 *Engg.*, 1/1/26, 15/1/26, 12/2/26, 26/2/26, 19/3/26	1922	Manchester Corporation	Barton (Manchester)	82,500	160,000	27,500	350	700	
3	Inst. Mech. Engrs., No. 3, 1925, 689–694	1924	Detroit Edison Co.	Trenton Channel (Detroit)	150,000	300,000	50,000	375	700	
4	*Power*, 12/5/25, 720 *Elect. World*, 25/2/25	1924	Ohio Power Co.	Philo	80,000	240,000	40,000	550	725	Reheating to 725° F.
5	*Elect. World*, 18/7/25 *Elect. Review*, 22/6/25 *Power*, 16/6/25	1925	Commonwealth Edison Co.	Crawford-avenue (Chicago)	160,000	750,000	50,000 60,000	550	725	Reheating to 725° F.
6	The Engineer, 22/5/25, 568	1925	County of London E.S. Co.	Barking (London)	120,000	500,000	20,000 40,000	350	700	Reheating to 700° F.
7	*Power*, 30/12/24 *Elect. World*, 15/12/25, 22/12/25	1925	Columbia Power Station	Columbia (Miami Fort)	90,900	360,000	45,000	550	725	Reheating to 725° F.
8	*Power*, 14/4/25, 15/9/25	1925	Edison Electric Illuminating Co. of Boston	Weymouth	82,900	400,000	(3 × 3,150) (32,000)	1,200 350	700 700	
9	*Elect. World*, 23/5/25, 1074	1926	Philadelphia Electric Co.	Richmond	100,000	600,000	50,000	375	675	
10	*Power*, 19/5/25	1926	New York Edison Co.	East River (N.Y.)	120,000	700,000	60,000	375	700	
11	*Elect. World*, 3/5/24, 23/5/25	1924 1926	Brooklyn Edison Co.	Hudson-avenue	150,000 240,000	400,000	50,000 90,000	265 375	614 700	
12	*V. d.I.*, 10/10/25, 1288	1927	Berliner Elektrizitätswerke	Rummelsburg (Berlin)	240,000	600,000	70,000 10,000	462	752	
13	The Engineer, 4/6/26	1925	Centrales Electriques des Flanders	Langerbrugge	26,400		(1,600) (6,600)	710	822	

* Paper read before the North-Western Branch of the Institution of Mechanical Engineers.

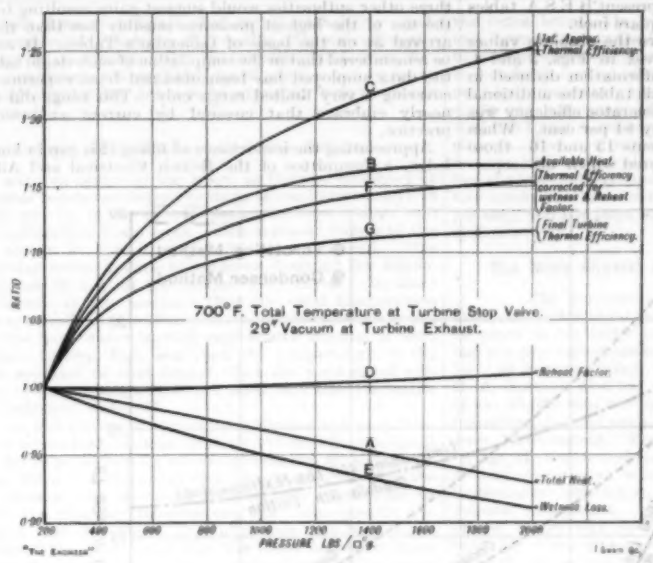


FIG. 3

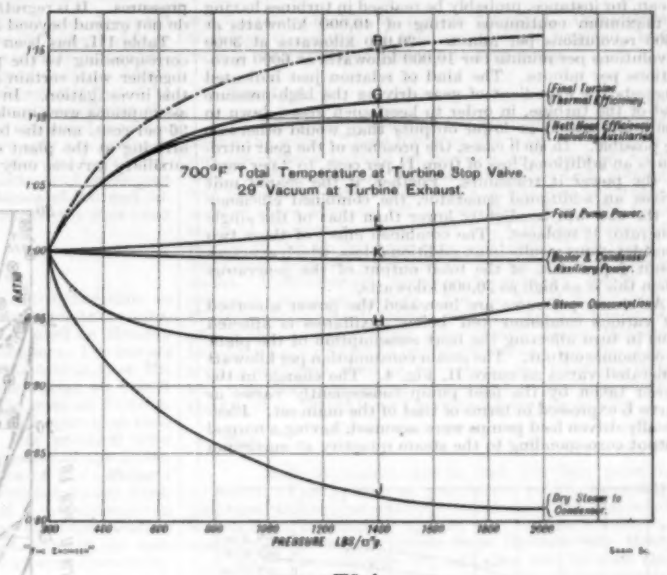


FIG. 4

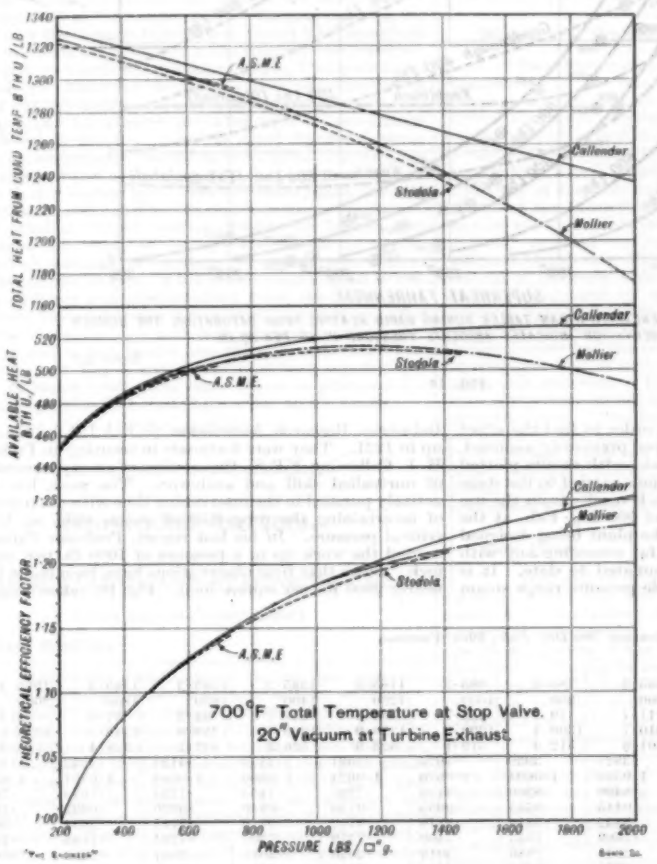


FIG. 5

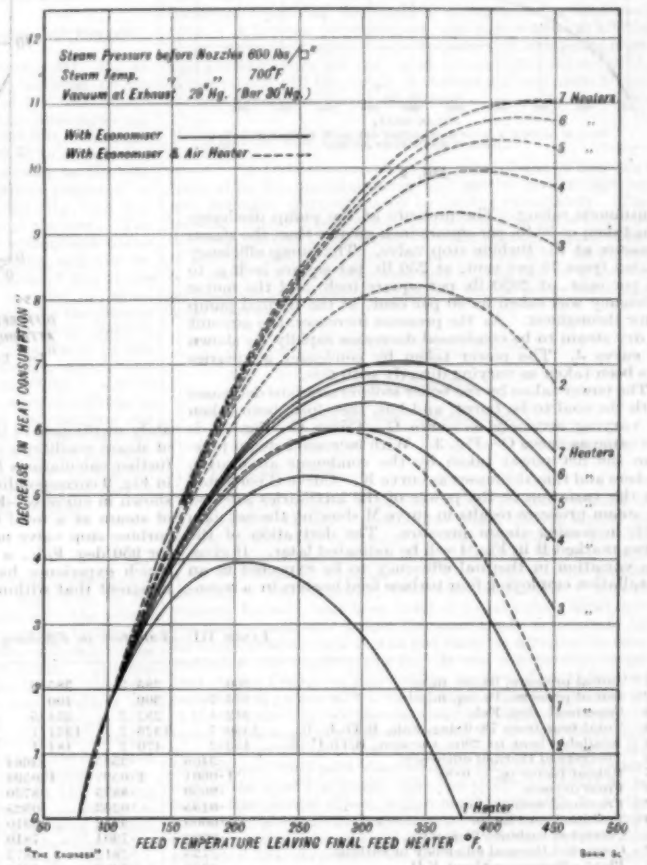
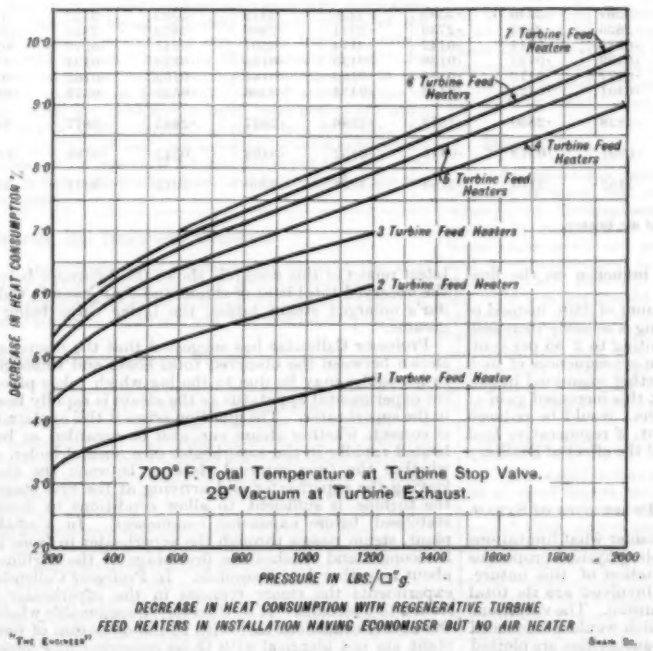
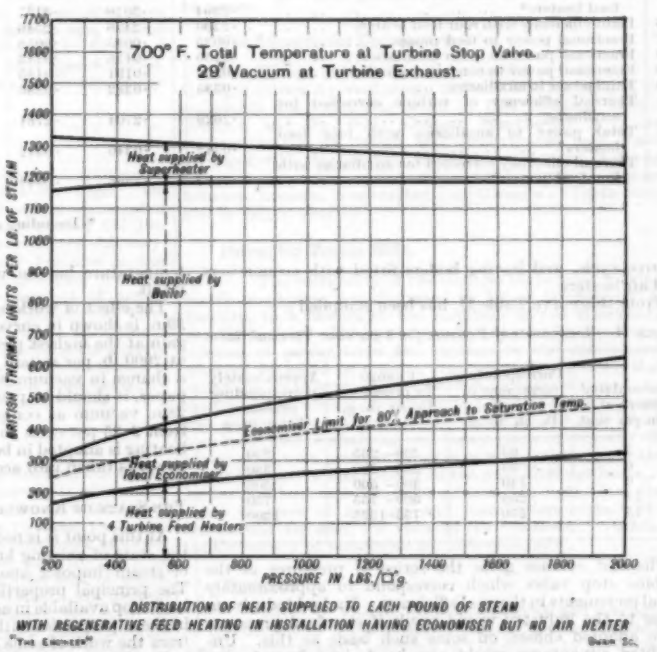

Steam Pressure before Nozzles 600 lbs/□"
Steam Temp. " " 700°F
Vacuum at Exhaust 29"Hg. (Bar 30"Hg.)
With Economiser
With Economiser & Air Heater
7 Heaters
1 Heater
FEED TEMPERATURE LEAVING FINAL FEED HEATER °F.

FIG. 6


7 Turbine Feed Heaters
6 Turbine Feed Heaters
5 Turbine Feed Heaters
4 Turbine Feed Heaters
3 Turbine Feed Heaters
2 Turbine Feed Heaters
1 Turbine Feed Heater
700° F. Total Temperature at Turbine Stop Valve.
29" Vacuum at Turbine Exhaust.
PRESSURE IN LBS./□"g.

DECREASE IN HEAT CONSUMPTION WITH REGENERATIVE TURBINE FEED HEATERS IN INSTALLATION HAVING ECONOMISER BUT NO AIR HEATER

FIG. 7


700° F. Total Temperature at Turbine Stop Valve.
29" Vacuum at Turbine Exhaust.
Heat supplied by Superheater
Heat supplied by Boiler
Economiser Limit for 80° Approach to Saturation Temp.
Heat supplied by Ideal Economiser
Heat supplied by 4 Turbine Feed Heaters
PRESSURE IN LBS./□"g.

DISTRIBUTION OF HEAT SUPPLIED TO EACH POUND OF STEAM WITH REGENERATIVE FEED HEATING IN INSTALLATION HAVING ECONOMISER BUT NO AIR HEATER

FIG. 8

it can, for instance, probably be realised in turbines having a maximum continuous rating of 40,000 kilowatts at 1500 revolutions per minute; 20,000 kilowatts at 3000 revolutions per minute; or 10,000 kilowatts at 6000 revolutions per minute. The kind of relation just indicated suggests the expedient of gear driving the high-pressure end of the turbine, in order to keep such losses down to the limits stated at lower outputs than would otherwise be possible. In such cases, the presence of the gear introduces an additional loss of from 1¼ per cent. to 2 per cent. of the power it transmits. Further, if the geared unit drives an additional generator, the combined efficiency of the two will be slightly lower than that of the single generator it replaces. The combined effect of these two considerations results in an additional loss, which averages about ¾ per cent. of the total output of the generators when this is as high as 20,000 kilowatts.

As steam pressures are increased the power absorbed by various condenser and boiler auxiliaries is affected thus in turn affecting the heat consumption of the plant at economic output. The steam consumption per kilowatt generated varies as curve H, Fig. 4. The change in the power taken by the feed pump consequently varies as curve L expressed in terms of that of the main set. Electrically-driven feed pumps were assumed, having a normal output corresponding to the steam quantity at maximum

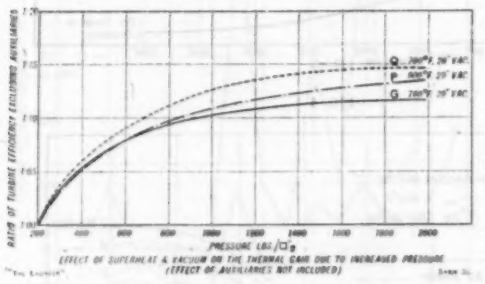

RATIO OF TURBINE EFFICIENCY EXCLUDING AUXILIARIES
PRESSURE LBS./□"
EFFECT OF SUPERHEAT & VACUUM ON THE THERMAL GAIN DUE TO INCREASED PRESSURE
(EFFECT OF AUXILIARIES NOT INCLUDED)

FIG. 9

continuous rating. The pressure at the pump discharge was taken as 50 lb. per square inch greater than the steam pressure at the turbine stop valve. The pump efficiency varied from 75 per cent. at 250 lb. per square inch g. to 65 per cent. at 2050 lb. per square inch, and the motor efficiency was taken as 90 per cent. at the normal pump duty throughout. As the pressure increases, the amount of dry steam to be condensed decreases rapidly, as shown in curve J. The power taken by condenser auxiliaries has been taken as varying directly with this.

The power taken by the boiler stokers and fans decreases with the coal to be burnt, and has, therefore, been taken as varying inversely as curve G. Curve G—Fig. 4—is the same as curve G—Fig. 3. With increased steam pressure the net power taken by the condenser auxiliaries, stokers and fans decreases as curve K. Curve G corrected for the variation in the power of the auxiliaries affected by steam pressure results in curve M showing the net gain with increasing steam pressure. The derivation of the curve marked R in Fig. 4 will be indicated later. It gives the variation in thermal efficiency to be expected in an installation employing four turbine feed heaters in a regenerative cycle, and having boilers fitted with economisers and air heaters.

From this curve Table II. has been compiled :—

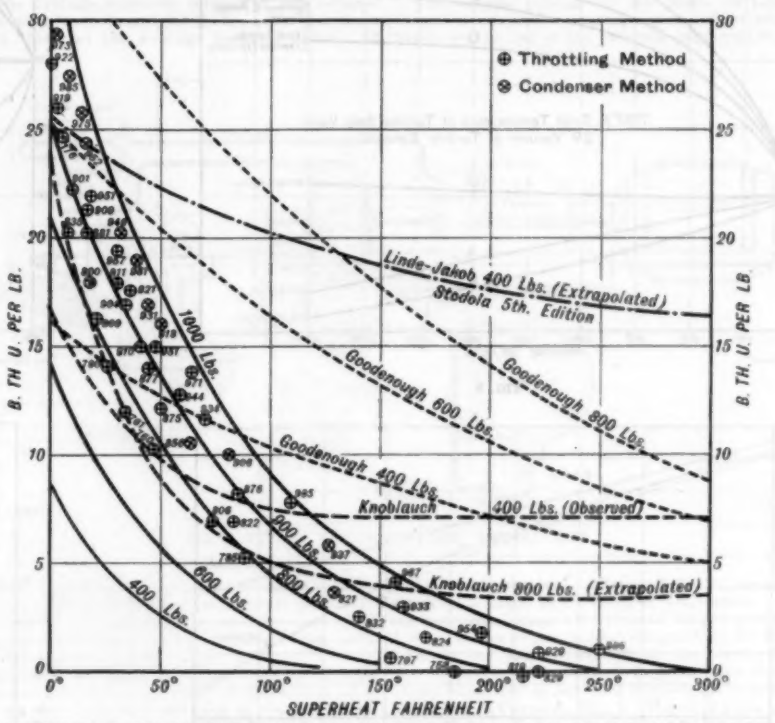
TABLE II.—*Increments of Pressure for 3 per cent. Thermal Gain.*

Accumulated thermal gain per cent.	Corresponding increment in pressure, lb. sq. in. g.	Change in pressure, lb./sq. in. g.	Approximately corresponding pressure, lb./sq. in. g.
3	65	200– 265	250
6	95	265– 360	350
9	140	360– 500	500
12	255	500– 755	750
15	570	755–1325	1300

The last column gives the series of pressures at the turbine stop valve which correspond to approximately equal increments in thermal efficiency. Undoubted advantages to the industry would result if standard pressures were adopted chosen on some such basis as this. Undoubted advantages would also be derived from laying down and agreeing standard flanges to be adopted for such pressures. It is regrettable that at present B.E.S.A. tables do not extend beyond 325 lb. per square inch.

Table III. has been added to give the absolute values corresponding to the principal curves in Figs. 3 and 4, together with certain additional information deduced in this investigation. In preparing this table the additional assumptions were made, that the generator efficiency was 96 per cent. and the boiler efficiency 84 per cent. When arriving at the plant efficiency—items 13 and 16—those auxiliary services only were considered which are separately mentioned in the table. In order to find the effect of steam conditions other than those previously assumed, further calculations have been made, with results plotted in Fig. 9 corresponding to calculations carried to the stage shown in curve G—Fig. 3. Curve P results from the use of steam at a total temperature of 900 deg. Fah. at the turbine stop valve necessitating the plant being designed for 950 deg. Fah., a temperature far exceeding any with which experience has been accumulated to date. It is apparent that within a considerable pressure range steam temperature has no very sensible influence on the final result.

The effect of working with a vacuum of 28in. instead of 29in. is shown in curve Q, indicating a sensibly increased gain at the highest pressures amounting to 2·85 per cent. at 2000 lb. per square inch. As the consequences of such a change in vacuum will not be further examined in this paper, it should be pointed out that this increased gain at 28in. vacuum as compared with 29in., would be reduced from 2·85 per cent. to 2·05 per cent. if regenerative feed heating is adopted in both cases, and the effect of auxiliary power is taken into account.



DIFFERENCE △ H FROM ENLARGED STEAM TABLES DURING RAPID HEATING FROM SATURATION. THE NUMBER ATTACHED TO EACH OBSERVATION INDICATES ABSOLUTE PRESSURE IN LB. PER SQ.IN.
"THE ENGINEER" SWAIN SC.

FIG. 10

TABLE III.—*Variation in Efficiency with Steam Pressure, 700 Deg. Fah., 29in. Vacuum.*

1	Initial pressure, lb./sq. in. g.	200	285·3	385·3	485·3	585·3	785·3	985·3	1185·3	1385·3	1585·3	1785·3	1985·3
2	Initial pressure, lb./sq. in. abs.	214·7	300	400	500	600	800	1000	1200	1400	1600	1800	2000
3	Superheat, deg. Fah.	312·1	282·2	254·5	231·4	211·7	179·1	152·7	130·3	110·7	93·3	77·6	63·2
4	Total heat from 78·9 deg. Fah., B.Th.U./lb.	1330·7	1326·2	1321·1	1315·9	1310·7	1300·4	1290·0	1279·9	1269·4	1259·0	1248·7	1238·4
5	Available heat to 29in. vacuum, B.Th.U./lb.	453·2	470·2	484·1	494·1	501·6	512·3	519·1	523·6	526·3	527·7	528·4	528·2
6	Theoretical thermal efficiency	·3406	·3545	·3664	·3755	·3827	·3939	·4024	·4091	·4146	·4191	·4232	·4265
7	Reheat factor ($\eta_r = 0·8$)	1·0601	1·0597	1·0594	1·0592	1·0594	1·0604	1·0620	1·0624	1·0666	1·0686	1·0701	1·0711
8	Final dryness	·9050	·8875	·8720	·8595	·8490	·8300	·8130	·7980	·7855	·7755	·7675	·7615
9	Frictional wetness loss	·0185	·0253	·0325	·0385	·0445	·0555	·0655	·0750	·0840	·0920	·0992	·1050
10	Turbine losses factor	1·0000	·9952	·9910	·9878	·9852	·9810	·9778	·9752	·9729	·9711	·9694	·9679
11	Corrected turbine efficiency	·8000	·7904	·7810	·7733	·7669	·7553	·7460	·7379	·7307	·7244	·7186	·7139
12	Corrected thermal efficiency of turbine	·2735	·2812	·2873	·2915	·2945	·2986	·3013	·3030	·3041	·3047	·3052	·3056
13	Plant efficiency without F.H.	·2206	·2268	·2317	·2351	·2375	·2408	·2430	·2443	·2452	·2457	·2461	·2464
14	Fractional gain with four feed heaters*	·0772	·0842	·0899	·0936	·0986	·1060	·1121	·1183	·1243	·1302	·1360	·1420
15	Corrected turbine thermal efficiency with four feed heaters*	·2964	·3070	·3157	·3216	·3267	·3340	·3393	·3436	·3473	·3503	·3532	·3562
16	Plant efficiency with four feed heaters*	·2390	·2476	·2546	·2593	·2635	·2693	·2736	·2771	·2800	·2825	·2848	·2872
17	Fractional power to feed pump	·0035	·0045	·0058	·0071	·0085	·0114	·0142	·0174	·0207	·0241	·0277	·0315
18	Fractional power to boiler auxiliaries	·0150	·0146	·0143	·0141	·0139	·0137	·0136	·0135	·0135	·0135	·0134	·0134
19	Fractional power to condenser auxiliaries	·0200	·0191	·0185	·0180	·0177	·0172	·0168	·0165	·0164	·0163	·0162	·0162
20	Total power to auxiliaries	·0385	·0382	·0386	·0392	·0401	·0423	·0446	·0474	·0506	·0539	·0573	·0611
21	Thermal efficiency of turbine corrected for auxiliaries	·2629	·2704	·2761	·2799	·2828	·2860	·2879	·2886	·2887	·2883	·2877	·2869
22	Total power to auxiliaries with four feed heaters*	·0342	·0340	·0342	·0345	·0351	·0379	·0411	·0452	·0498	·0542	·0596	·0644
23	Thermal efficiency corrected for auxiliaries with four feed heaters*	·2863	·2966	·3049	·3105	·3152	·3213	·3253	·3281	·3300	·3313	·3321	·3332

* Including economiser and air heater.

THE STATE OF KNOWLEDGE OF THE PROPERTIES OF STEAM.

At this point it is necessary to consider what limitations the state of existing knowledge of the physical properties of steam imposes upon an examination of this nature. The principal properties of steam involved are its total heat drop available in adiabatic expansion. The variations in these properties with pressure which would be deduced from the work of some of the major authorities are plotted in Fig. 5, page 535. From the resulting thermal efficiency ratios which are also shown, it will be gathered that the three other authorities would suggest gains resulting from the use of the highest pressures sensibly less than those arrived at on the basis of Callendar's Tables. It must be remembered that in the compilation of such steam tables the data employed has been obtained from experiments covering a very limited range only. This range did not nearly embrace that covered by current engineering practice.

Appreciating the importance of filling this gap in knowledge, a Committee of the British Electrical and Allied Industries Research Association (B.E.A.I.R.A.) was set up in 1921. They were fortunate in securing in Professor H. L. Callendar, F.R.S., the services of an experimentalist of unrivalled skill and authority. The work has been actively pursued in the intervening time with the intention of ascertaining the properties of steam right up to the critical pressure. In his last report, Professor Callendar carried the work up to a pressure of 1000 lb. per square inch. Since that time observations have been made up to nearly 2000 lb. per square inch. Fig. 10, taken from the latest report of this research, shows the difference between the observed total heat of steam and that given in Callendar's enlarged steam tables, the latter value being the greater.

Professor Callendar has suggested that the discrepancy shown between the observed total heats and those given in his tables may be due to the lag which takes place in his experimental apparatus as the steam is rapidly heated in the superheater. The question arises if this explanation is correct, whether steam can also be regarded as being heated rapidly in the superheater of a normal boiler, and whether the time interval elapsing between the steam leaving the superheater and arriving at the first stage of the turbine is sufficient to allow conditions to become stabilised before expansion commences. In a modern plant, steam passes through the superheater in from 1 to 3 seconds, and reaches the first stage of the turbine in about a further 1 to 3 seconds. In Professor Callendar's experiments the steam remains in the superheater for from 2 to 5 seconds. It is, therefore, questionable whether the actual conditions met with in the operation of power plant are not identical with those occurring in Professor Callendar's experiments. Such questions cannot be completely answered at the present time, but sufficient work

has been done to indicate that in all probability such modification in estimates of possible thermal efficiency as may be necessary when the experimental work has been completed, will probably be of such a nature as to decrease slightly the gains to be expected from increased pressure.

EFFECT OF REGENERATIVE FEED HEATING.

In order to arrive at the effect on thermal efficiency of the use of regenerative feed heating, several pressures from 200 lb. per sq. in. to 2000 lb. per sq. in. were chosen, and an investigation made from which series of curves of the type shown in Fig. 6, page 535, were deduced. This particular series applies to turbines designed for 600 lb. per square inch g. at the turbine stop valves. In these calculations it was assumed that the total temperature rise was equally divided between the feed heaters concerned that the feed water leaving any heater reaches a temperature 10 deg. Fah. less than the temperature of the steam supplied to that heater, that the mechanical efficiency of the turbine was 98 per cent., and that the radiation coefficient was 1·05.

Of the two groups of curves for systems employing from one to seven feed heaters, that shown in full lines holds for a boiler plant having an economiser but no air heater. Under these conditions as the temperature leaving the feed heaters, and therefore entering the economiser, is raised, the chimney temperature, and consequently the chimney loss also rises. Due allowance has been made for this on the assumption that the boiler and economiser remain the same for all feed temperatures. The series shown in dotted lines applies to a boiler plant fitted with both an economiser and an air heater; the latter so proportioned that as the temperature of the gases leaving the economiser increases, it transmits sufficient additional heat to the incoming air to maintain the chimney loss constant. From such curves the results shown in Fig. 7 were obtained in which the maximum decrease in heat consumption is plotted against steam pressures for from one to seven feed heaters in an installation provided with an economiser but without air heaters. It will be noted that the decrease in heat consumption is continuous with increasing pressure, being almost twice as great at 2000 lb. per square inch as at 200 lb. per square inch. On the other hand, the rate of increase is most rapid for the first increase in pressure.

The number of feed heaters chosen for further consideration, *i.e.*, four, is perhaps more than is usually adopted at present. A constant number of feed heaters has been chosen in spite of the rather smaller gain in efficiency at lower pressures resulting from the addition of the fourth heater, because its inclusion is equally justified when the increasing cost with increasing pressure of incorporating such a feed heater into the system is taken into account. In Fig. 8 the quantity of heat supplied per pound of steam from each main source is plotted for a system employing four feed heaters but no air heater.

(To be concluded.)

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Trade Situation.

THE slight improvement in the coal situation has once more raised hopes of an approaching settlement, though painful experience has prevented any great reliance being placed on the somewhat brighter outlook. The immediate effect is to discourage buying of iron and steel, for it is believed by Midland industrialists that peak prices have now been reached, and that orders will be more profitably placed in the near future. At the moment the industrial position in the Midlands and Staffordshire is little changed. The heavy industries show little activity, but arrangements are being made for a big rush of business immediately the strike is over and fuel is readily obtainable again. There is a good deal of inquiry proceeding, but the difficulty of gauging prices anything like accurately prevents business being definitely placed. Some of the South Staffordshire factories are rather busy in certain departments, and on 'Change in Birmingham to-day there was some talk of an early resumption being made at one important concern in the production of steel. Some of the iron mills at these works have been active for some time. In the Black Country another mill is going, but at one of the largest and best equipped steel works in this area there is no prospect of a resumption yet awhile. The position is not sufficiently clear, and fuel supplies are too short at present.

Brierley Hill Ironworks Reopened.

Operations were resumed this week at the Earl of Dudley's Old Level Ironworks, which have been closed since the commencement of the coal dispute, and at which, in normal times, between 300 and 400 men are employed.

Colliers' Unprecedented Output.

The number of miners returning to the pits in the Midland coalfields continues to grow, and the output from the respective collieries increases accordingly. A rather surprising and gratifying occurrence in the Cannock Chase area is that unprecedented output is being achieved. Loaders who were previously earning £2 10s. per week are now picking up from £4 10s. to £5 a week, and stallmen are receiving over £1 a day. This is partly due to a profit sharing scheme recently introduced by the Cannock Chase Collieries, Ltd. Mr. S. F. Sopwith, the company's general manager, said this week that his standard since the resumption of work had been that the man who could produce an output which was equal to a good week's pre-strike output plus one-seventh for the additional hour now in operation should have the bonus promised under the profit-sharing scheme. That objective had been easily attained, and the men's output was very much greater now for the seven hours' period apart from the added possibilities of the extra hour. The output, he pointed out, depended to a large extent on the loader, and the difficulty had been to get him sufficiently interested in his work to induce him to put forth special efforts to get a good output. Being paid by a day-rate wage, the loader always felt that if he made any additional effort it was simply to enable the stallmen to get more money. That, he explained, was now altered. The new scheme helped not only the stallmen and the loaders, but all the day wage men and boys handling the coal underground and on the surface. For the past two weeks the men had received a bonus of 3d. and 2d. per day, and the boys 1½d. and 1d. respectively over their ordinary wage.

The Notts Miners' Breakaway.

The movement initiated in Nottinghamshire in favour of a settlement with the owners upon district terms, as noted in my letter last week, culminated on Monday last in a protracted conference at Nottingham. The owners had, as a preliminary, required the assurance that Mr. G. A. Spencer and his colleagues were acting on behalf of the 40,000 men who have returned to work at Nottinghamshire pits, and satisfactory guarantees upon that head were forthcoming. The conference was presided over by Mr. H. Eustace Mitton, a representative of the Notts. colliery proprietors who are members of the Midland Coalowners' Association and of the Erewash Valley Coalowners' Association. At the close of the conference an official report was issued stating that after consultation with Mr. Spencer and other representatives of the men at work, the owners' representatives had agreed to recommend an early conference between the parties with a view to drawing up and completing a district agreement.

Birmingham Drainage Projects Costing £4,250,000.

The Birmingham City Surveyor—Mr. H. H. Humphries—in his recent presidential address to the Birmingham and District Association of the Institution of Civil Engineers, referred to Birmingham drainage engineering projects which would cost £4,250,000. Surveys, he said, had been made of the rivers Rea, Tame, Cole and the Hockley Brook, which gave vital service to the city in the way of drainage and tentative schemes prepared for improving the Tame from the Trent to the city, and also the Cole and the Rea as far as they affected the city. The proposals included the increase of the waterways under bridges and culverts, the removal of shoals, and the regrading of the river beds. The inclination of the rivers would be improved by altering their courses, in some instances by the substitution of straight cuts for the present serpentine courses. One serious problem near Salford Bridge consisted of the crossing of the river Tame by the Birmingham and Warwick Canal Aqueduct, which had insufficient waterway. His proposal regarding it was to remove the three arches and substitute steel troughing to carry the canal. The tentative scheme for carrying out the whole of the improvements required, from the river Trent upward, comprised works estimated to cost approximately four and a quarter million pounds. He emphasised the fact that such schemes could only be carried out in instalments and upon extensive regional methods.

Steel Hopes.

Irrespective of the issue of the coal negotiations, there are hopes that the production of steel may be resumed in Staffordshire very soon. Meanwhile, the return to work of large numbers of Midland miners has facilitated operations at some of the re-rolling works, especially those that have collieries in association with them. Outcrop coal, supplies of which are steadily maintained, has also proved a valuable resource. Most of the re-rollers are dependent on continental half-products. Stocks are very sparse, and congestion at Antwerp continues to increase the hazard of trading. District mills have in some instances been stopped owing to delayed deliveries. Prices of continental steel are strong. There is a lull in the placing of large business for engineering requirements, most buyers considering the present high prices will give way as soon as settled conditions return. The few transactions negotiated this week have been at enhanced prices. As much as £9 10s. has been paid for angles, provided prompt delivery could be given. Orders have been taken for execution after the coal settlement at £8 10s. These rates show an advance of 15s. on those ruling a month ago. Small quantities of steel bars can still be bought at £8 15s. if customers are not too exacting in their specifications. It is still practically impossible to secure either ship, bridge and tank or boiler plates.

Sheet Values.

Galvanised sheet values continue to appreciate. Demand is good and production costs are high. On 'Change in Birmingham to-day galvanised corrugated sheets, 24 gauge, were pretty generally quoted £17 10s. Some mills could not promise delivery before January, and were unprepared to entertain new business at less than £17 15s. Here and there lower figures were heard of, but this was attributed to a certain amount of underselling on the part of merchants. Tin-plates, too, have appreciated further, being quoted up to £1 6s. Manufacturers are very chary about committing themselves more deeply. The scarcity of wasters in this district is accentuated. So little business is passing that the price level is not clearly defined, but £1 4s. is mentioned.

Finished Iron.

Isolated ironworks have started in South Staffordshire to meet urgent orders, though activity is necessarily limited. Buying and selling are conducted within very cramped lines, and producers are able to name their own terms to a great extent. One firm is this week reported to have realised up to £15 per ton for medium iron. A typical contract was for wrought iron, the lack of which was keeping back a large consignment of steel. Any general resumption of work at the mills, however, is not to be looked for at present. Black Country manufacturers of nuts and bolts and fencing material were pleased to see this week that some Belgian houses had reduced their quotations for No. 3 bars by 1s. 3d. per ton, making the now quotation £6 16s. 3d. per ton delivered. Complaints of delays in delivery of this material are frequent, but most of the works are managing to keep going.

Raw Iron.

The pig iron situation has not materially changed during the week. Those furnaces which are still in operation are not now anxious for business, and prices are very firm. Durham foundry pig iron, which has been coming into this district rather more freely of late, has undergone another sharp advance, till it is not much below the high levels of Cleveland makes. For No. 1 Durham furnaces require £6 16s. 3d. delivered here, and for No. 3, £6 11s. 3d. They now hold out prospects of delivery in four to six weeks. Middlesbrough furnaces occasionally accept an order for December delivery. For No. 3 G.M.B. pig iron, £7 delivered in this district is quoted. To this has to be added the ever-increasing coke prices. Many Midland foundries have refused to buy at this price; but, the engineering concerns, even at this stage, get what pig iron and coke they can, as an alternative to shutting down their works. There is no East Coast hematite on offer.

Fuel.

Midland manufacturers find the fuel position no easier. Fuel is now at prohibitive prices, especially for those trading undertakings which have no chance of indemnifying themselves against the burden. Notwithstanding the increased output from Midland pits, there is no more fuel available for industrial use, because the requirements of the domestic consumer are so much greater now that winter is upon us. The Birmingham and Staffordshire foundries are entirely dependent on imported coke. A certain proportion of gas coal is now available from pits in the Derby–South Yorkshire–Nottingham area, and gas engineers are very glad to avail themselves of it. While it costs £2 15s. to £3, American gas coal costs round about £4 delivered in the Midlands.

Price of Gas Power Increased.

A further increase in the price of gas in Birmingham, alike for manufacturing and motive power, lighting and domestic purposes is to be made immediately. The need for this is directly due to the coal dispute, which has involved the Gas Department in heavy costs in the purchase of foreign coal. The increase announced is an all-round one of 4d. per 1000 cubic feet and follows one of a similar amount made in August. Coke and breeze prices have also been increased.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

The Steel Cartel.

THE opinion that one of the primary results of the recently formed continental Steel Cartel would be higher prices for continental steel on export markets received the support of the Hon. Roland D. Kitson, chairman of Bolckow, Vaughan and Co., Ltd., at the annual meeting of the company, held here on Monday. British makers, he said, had been invited to join the Cartel, and the matter was now before the steel trade as a whole for its consideration, but it was too early to attempt to forecast what the result might be. It was the avowed intention of the Cartel to prevent the export of semi-finished materials at prices which would enable the foreign buyers of these materials to compete with the finished products of home industries. It was not unfair to deduce from this, and the further fact that the motive which induced the formation of this pact was the desperate cutting of prices during the past few years, that the tendency would be to stiffen continental prices, which must inevitably be to the advantage of the British steel trade. A satisfactory feature of the chairman's address was his statement that the company has at present on its books orders which will ensure for its steel plant employment at a higher rate of production than before the stoppage for many months to come.

The Ljungstrom Locomotive.

With a view to ascertaining the performance of the Ljungstrom type of steam turbine locomotive and its suitability for main line work in this country, Beyer, Peacock and Co., Ltd., Gorton, Manchester, who are responsible for its design and construction here, have arranged with the London, Midland and Scottish Railway to test it on suitable express trains on the company's system between London, Manchester and Glasgow. These tests will be begun shortly.

Drives for Textile Mills.

The suitability of the impulse turbine for driving textile machinery was discussed by Mr. J. Greenwood, of Bedford, in a lecture to the members of the Blackburn Textile Society. The method to be adopted for the transmission of power from the turbine to the machinery, whether by ropes or motors, was, he said, a matter that called for consideration in respect of local conditions. An electric drive, with motors arranged on the group system, was particularly suitable in the case of an old mill which had long lines of shafting and many pairs of wheels. If, however, it were possible to arrange a rope drive from the turbine to one or more shafts in the mill, that method was by far the best and the most economical, both from the point of view of running and installation costs. Mr. Greenwood discussed the value of the "pass-out" turbine for the supply of process steam in textile mills.

Personal.

Mr. S. L. Pearce, formerly engineer and manager of the electricity department of Manchester Corporation, and now Electricity Controller in London, is to have conferred on him at the University of Manchester on November 17th the honorary degree of D.Sc.—Mr. Tom Makemson,

since 1922 honorary secretary of the Lancashire Branch of the Institute of British Foundrymen, has just been appointed general secretary of the Institute. Mr. Makemson, who is a member of the research staff at the Trafford Park works of the Metropolitan-Vickers Electrical Manufacturing Company, Ltd., is well known in Manchester engineering circles, and during the last few years has delivered papers on various aspects of foundry practice before technical associations in Lancashire.

Non-ferrous Metals.

Since the non-ferrous metals market was reviewed in this column a week ago, the tin market has displayed movements which have been remarkably erratic, even for this metal. Early heavy selling further depressed values after the sharp decline experienced in the previous week, but later the £300 mark was again passed in the case of cash metal, to be followed at the close of the week by a rather serious relapse. The present week opened on a healthier tone, and with a more active buying movement prices again soared. This has since been maintained, and at the time of writing, cash tin is in the neighbourhood of £310, with forward metal just below £300. What the future holds in store is made the more uncertain by the nervous condition of the market. It is probable, however, that further serious fluctuations will be experienced during the next week or two. The demand for copper has continued rather quiet and the tendency of prices has again been easy, although in the last day or two there has been a slight recovery. The avowed policy of the Copper Export Association has been outlined in an official statement by the president of that body, the primary function apparently being to avoid the wide fluctuations in prices that result largely from the operations of purely speculative interests. As regards marketing, it is stated that an effort will be made to sell direct to consumers except where conditions make it desirable in facilitating export trade to sell to distributors. Copper prices in Europe, it is affirmed, will be established in accordance with general business conditions as they develop from day to day. Both lead and spelter are a turn steadier now after weak spells.

Iron.

With supplies of pig iron still very scarce, prices on this market have remained firm throughout the past week, with Scottish ranging from 137s. 6d. to 150s. per ton delivered Manchester—the latter figure being a special case—with Middlesbrough at 137s. 6d. to 140s., some miscellaneous hematite iron at about 120s. per ton, and a little East Coast foundry iron at 132s. 6d. delivered. Apart from these brands, which are offered very sparingly, there is virtually nothing available, and so far no indication of a possible resumption of operations at the Midland blast-furnaces. Lancashire bar iron manufacturers have again increased quotations by 10s. per ton—the third by a similar amount since the beginning of May—making current values £12 10s. delivered for Crown quality bars and £11 5s. for second quality. These prices relate to deliveries after normal production restarts. In one or two instances where supplies of semi-finished iron are held in stock, attempts are being made to manufacture a limited quantity of bar iron, but as this entails the use of high-priced coal, prompt deliveries are only being executed at a premium on the latest official prices mentioned above.

Steel.

Here and there attempts are being made to relieve the steel situation by a partial resumption of rolling mill operations, but the result is not such as to affect the position to any material extent. With the continued uncertainty as to the incidence of fuel costs on production charges, there is little anxiety to entertain forward business, and values remain to a large degree nominal at from £9 to £9 10s. for basic steel bars, £11 10s. to £11 15s. for boiler plates, £8 10s. to £8 15s. for tank plates, and £7 17s. 6d. to £8 2s. 6d. for joists and sections delivered Manchester or equal. Coal difficulties and the scarcity of semi-finished steel are responsible for the continued firmness of re-rolled bars, which cannot be bought here now at less than £10 per ton. For continental steels prices are nominally firm and unchanged, but it is possible to meet with offers of material from second hands at cut rates. For delivery to Manchester for cash against documents, billets are about £6 7s. 6d. per ton, wire rods at £7 2s. 6d. to £7 5s., sheet bars at £6 12s. 6d., Siemens plates at £7 15s., light plates at £6 10s., and joists and sections at £6 15s. to £6 17s. 6d. per ton. Galvanised sheets are firmer here at £17 10s. per ton f.o.b., but the market is so quiet that offers of merchant parcels at lower rates have failed to attract attention.

Scrap.

The market for non-ferrous metal scrap is quiet and uninteresting, with brass rod turnings offered at £40 per ton, selected gunmetal scrap at £53, clean light copper £57, zinc scrap £25, heavy yellow brass £45, and cast aluminium £75, for graded qualities delivered to users' works.

BARROW-IN-FURNESS.

Hematite.

This district has been following the various phases of the negotiations in the coal dispute very keenly, and the hope is expressed that soon the various local ironworks may be able to start on the fairly heavy orders which they hold. The position of the makers is reflected by the general tendency for prices to rise. This suggests that they are well situated for orders for many months. Certain of the important customers placed orders some time ago, and are well covered forward. Those who have hesitated will have to pay considerably higher prices. It is difficult to say whether prices will rise further, but it would not be at all surprising if they did. Apart from ordinary qualities there are many orders and further inquiries for special qualities.

Iron Ore.

As soon as fuel is available regularly in the district and the furnaces are put in blast, the local iron ore mines will benefit, for the demand will be better than it has been for years. The imports of foreign ores from Spain, Algeria and Kirkenes in Norway will also be resumed. With freights sent up by the demand for foreign coal, the bringing in of foreign ore has been out of the question. Certain stocks exist in the district.

Steel.

The steel market remains quiet, and prices have remained stationary, while iron has become dearer week by week. Orders are held by makers, but they were placed some months ago and the market has been quiet since. There may be a little more life when iron is being produced again, and there is some certainty as to date of delivery.

Shipbuilding and Engineering.

Shipbuilding has been badly hit by the coal dispute, for material has been held up. There is the Orient liner and the fast twin-screw passenger steamer for the Straits Settlements to get on with, and also the keel of the 600ft. submarine depôt ship to be laid. The cruiser Cumberland and the Donaldson liner Moldavia are being proceeded with at the fitting-out wharves and have not been interfered with very much. The contract which Vickers have secured from the Bibby Line to equip the two liners Dorsetshire and Somersetshire as Government transports is a fairly important one, for it means considerable internal alterations. These two ships are both modern, the one having been built in 1920 and the other in 1921. They are both 450ft. long and each has a registered tonnage of about 7500 tons. It is significant that these two vessels, both driven by internal combustion engines, should have been selected by the Government. In view of the fact that the submarine depôt ship is also to be driven by motors, it would seem that this method of propulsion is being more favourably viewed by the Admiralty. Engineers are busy at Barrow, and are likely to be considering the contracts now held locally.

SHEFFIELD.

(From our own Correspondent.)

Steel Trade Stagnant.

WITH the prospect of a settlement of the coal dispute in sight, there has naturally been the greatest caution shown in all trade movements this week. The few furnaces that are operating can only meet a very small proportion of the demand for steel. It is not true, as was stated recently in a London paper, that Sheffield firms are having to turn to a general buying of German steel. Some of this material is certainly coming into the district; but there is nothing remarkable about this. Small quantities of foreign billets have been coming in for some time, but their use is strictly limited. Foreign steel cannot solve Sheffield's problem, as it is not good enough in quality, and no development in trade can be looked for until the Sheffield, Rotherham and district furnaces get going again. In spite of the high price of coke, the crucible steel makers have decided to continue their operations, and have purchased further supplies of Westphalian coke at 79s. 6d. a ton delivered. This is an extraordinarily high figure, but it is less than the current quotation on the market, which is 80s. 6d. a ton. Makers are experiencing a heavy financial strain, for although the prices of crucible and electric steel have advanced a little, the extra amount nothing like meets the increased costs of production. There has been no alteration in the official quotations for high-speed steel.

Preparations for the Re-start.

Even if the coal dispute is settled almost immediately, it is doubtful whether the majority of the open-hearth steel furnaces will be producing material by the end of the year. It is reported that Cammell Laird and Co. and Steel, Peech and Tozer have large stocks of pig iron, and they should be melting metal in well under a fortnight after the settlement. Firms which have no reserves of pig will, of course, have to wait for deliveries from the blast-furnaces, and these again cannot get going until the coke ovens have got delivery of the necessary slack. It is not thought that the blast-furnaces will be producing pig in less than six or eight weeks after the termination of the dispute. One big problem that will face the iron and steel trades will be the price of fuel. There are authorities to be found who predict that fuel will be plentiful, and that there will be a slump in prices; but, on the other hand, contracts have already been fixed up provisionally at 2s. 6d. a ton more than the pre-stoppage quotations. From the point of view of the iron and steel trades, any advance in fuel prices will be a serious matter, and will be a big handicap in competition in foreign markets.

Coal Topics.

Well over 30,000 men are now at work in the Yorkshire collieries, though there has been nothing like a general drift back. A fair quantity of coal is available, and practically no difficulty is being experienced in meeting the claims of the priority services. A good deal of the outcrop coal being used for industrial purposes is not proving satisfactory at the moment, owing to the recent long spell of wet weather. Many of the workings have become damaged and water-logged, and coal is being delivered in a sodden condition. Serious complaints are being made about the delay in moving coal traffic by rail. But for this, the needs of industrial users of coal could be much more promptly met. In the Railway and Canal Commission Court, Mr. Justice Sankey has fixed December 14th for the hearing of an application by Pope and Pearson, of Silkstone Collieries, Altofts, for permission to work the Silkstone seam under 120 acres of land at Normanton, on the ground that there is a danger of the minerals being left permanently unworked, and that it is not practicable for any person other than the applicant company to work the minerals in question. At the annual meeting of the Denaby and Cadeby Main Collieries, Ltd., it was announced that there is to be an amalgamation of Denaby and Cadeby, Dinnington, Rossington and Maltby collieries. The combined outputs will be just under 4,000,000 tons, rising to 5,000,000 tons. The work will shortly be completed at Denaby and Cadeby Main on the new washers, electrical plant, boiler and pit tubs, on which over £300,000 has been spent. The upcast shaft at Denaby was drawing coal in December, and the output increased at once. Before the stoppage, 32,000 tons per week were being drawn, and the output should be up to 36,000 tons per week by the end of next year.

Engineering Plant for Quarries.

Members of the Institution of Quarry Managers who visited Sheffield last week were shown the extent to which the local engineering trade is associated with quarrying, cement making and kindred industries. They visited the works of Hadfields, S. Osborn and Co., and Edgar Allen and Co. The last-named firm is very busy on contracts for crushing and grinding machinery and cement plant. Among the exhibits on view were a combination ball and tube mill for grinding raw material; a portable batch-mixing and weighing machine for glass works sand; coal crushers and stone breakers. There was also a portion of a rotary cement kiln for the Barnstone Portland Cement Company, which is 150ft. long by 7ft. 6in. diameter, with an enlarged burning zone 8ft. 6in. diameter. The working of a small laboratory rotary kiln, 16in. diameter inside and 10ft. long, excited particular interest.

The Lighter Trades.

The production of files has been seriously curtailed as a result of the exhaustion of steel, but in any case there is a very poor demand for the finished article. A fair business is passing in saws and there is a brisk trade in all materials for the motor industry. There is work for several months ahead for the makers of special steels, forgings and drop stampings, and it is confidently expected that a lot more business will follow from the Show at Olympia. There is little fresh to report in the plate and cutlery trades. Except for a few odd orders the Christmas seasonal trade is at an end, and short time is being worked by the majority of firms.

Start of Big Sewage Scheme.

A start has been made by the contractors on the Staveley sewage scheme, which is estimated to cost about £90,000. Sheffield unemployed to the extent of nearly 90 per cent. of the labour, have been engaged. Most of the cast iron pipes used will be made by the Staveley Company. It will take about two years to complete the scheme.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade Prospects.

THE developments in the mining dispute during the last few days have created a feeling in commercial circles in the North of England that the end is really in sight, and there has been a disposition to discuss future business in most sections of trade. There is a general opinion that once the coal mines are in operation again trade will be quite brisk. Iron and steel producers are optimistic as to the prospects, despite the keen foreign competition which will have to be faced and the difficulty in regaining lost markets. Early release of orders is confidently expected, and works promise to be busy as soon as conditions admit of idle machinery being restarted. The shipbuilding industry on the North-East Coast, which has experienced nearly five years of acute depression, shows signs of revival. Already some activity is noticeable, and in addition to the number of orders placed recently, it is expected that several more will be given out when the coal dispute is ended. Unfinished vessels on the stocks are being sought after, and one on the Tyne and two on the Wear have been disposed of, the latest being a 6000 tons ship at the Tyne Iron and Shipbuilding Company's yard, which has been sold to Newcastle owners. The order for a sister liner to the Gripsholm for the Swedish-America line, which it was hoped would come to the Tyne, where the Gripsholm was built, has gone to Germany.

Cleveland Iron Trade.

Business is still confined within narrow limits on the Cleveland pig iron market, owing to the extreme scarcity of supplies, but there is a much more hopeful tone. There is a confident feeling that the coal dispute will quickly be ended, and thereafter there will be a wild scramble for supplies. No doubt the restarting of the iron and steel works will be a slow process, but with so much pressure for material it will certainly be expedited as much as possible. In the meantime, the market keeps steady. Home prices are unchanged, but foreign quotations are advancing, and as much as 100s. per ton c.i.f. has been asked for good foundry iron from abroad. Even at that figure it is doubtful if delivery could be assured before the end of the year, and consequently consumers needing prompt supplies must perforce buy from the local makers. No. 1 Cleveland foundry iron is 125s. per ton, No. 3 G.M.B. 120s., No. 4 foundry 119s. and No. 4 forge 118s. 6d.

Hematite Pig Iron.

With the usual marketable qualities of East Coast hematite iron unobtainable, the small business passing is confined to odd lots of off grades at prices varying from 87s. 6d. to 92s. 6d. per ton. Some little movement is noticeable, however, in the direction of arranging contracts for supplies when furnaces are re-kindled, and the opinion is expressed that for such delivery the quotation for mixed numbers should be about 92s. 6d. per ton.

Ironmaking Materials.

The foreign ore trade is still idle, and as consumers, in addition to having moderate stocks, have considerable deliveries to receive in fulfilment of orders placed before shipments were suspended, there seems little likeli-

hood of early resumption of sales. The situation as regards coke is still causing inconvenience to consumers. Supply is altogether inadequate, and the level of quotations has become almost prohibitive. Over 80s. per ton is stated to have been paid for foreign coke delivered to Cleveland works.

Manufactured Iron and Steel.

Manufacturers of finished iron and steel on the North-East Coast have quite good order books, and they report that substantial inquiries are circulating. Purchasing of continental semi-finished materials, and finished steel, by firms in this area has become much less active, owing largely, no doubt, to the difficulty of obtaining early delivery, but possibly also to the hope that local producers will be competing keenly with foreign manufacturers in the near future. Substantial premiums are being paid on the current minimum prices for early delivery of manufactured iron and steel.

The Coal Trade.

The position in the Northern coal trade continues to improve. All round there is a substantial increase in the numbers of men working as compared with a week ago, and the output per head is favourable. The production is readily disposed of at substantial prices, but, of course, financial results are not bright, owing to the standing charges which have to be distributed over a mere percentage of the total possible output. Still, fitters are pleased with the results, and look forward to a steadily improving position. Inquiries are coming more freely from abroad, but under present conditions exporters find that they cannot get any definite quotations, and have thus to await further developments. In spite of the fact that large orders for coal for delivery over the winter months have been lost, traders do not take an unfavourable view of the outlook. The coal reserves of most of the large utility undertakings at home and abroad will call for large replenishment immediately there is a general resumption of work at the collieries, and this alone should create a good demand for at least some months in the New Year. Business in imported coal is quiet on the North-East Coast. A number of cargoes for the remainder of this month and early December have been arranged for, but additional business is difficult to effect. Neither the utility companies nor other large consumers are anxious to commit themselves to purchase expensive imported coal for late December or for January deliveries, and transactions are in abeyance. Sellers offer good grade gas coals at 60s. per ton for end of the year delivery, but the price is not tempting.

Ironstone Miners' Wages Advanced.

An appreciable advance in wages has been conceded to the Cleveland ironstone miners. During the past quarter the wages stood at 63·5 per cent. above the base rates. According to the ascertainment of pig iron selling prices, the men during the current quarter were entitled to 64·3 per cent. above the base rates. An additional 5 per cent. is usually allowed, but after a conference with the men's representatives, the owners conceded another 5 per cent., bringing the total to 74·3 per cent. above the base rates. This represents an increase on last quarter's wages of 10·8 per cent., and it has been agreed that the wages rates as now fixed shall continue in operation until the end of March.

SCOTLAND.

(From our own Correspondent.)

Markets Quiet But More Hopeful.

The course of events during the past few days has engendered a much more hopeful feeling with regard to an early termination of the coal strike. Markets continue more or less inactive, but interest is growing, and evidence is not lacking that general opinion favours a very early resumption at many works at present inoperative. Certainly some little time must necessarily elapse before production could be re-established on lines similar to those prevailing prior to the strike; but the fact that a restart is considered imminent is evidenced by the stimulated interest in markets.

Coal Mining at Kilbarchan.

For many years it has been known that coal seams existed in the neighbourhood of Kilbarchan, Renfrewshire, but it is only within the past week or two that work on these seams has been started. Only a few skilled miners are yet employed, but it is hoped to increase the output considerably in the near future. The seam at present being worked is near to the surface, and excavation is by the method of "tunnelling." At present the miners are working in three shifts of eight hours each.

Steel and Iron.

Conditions in the Scottish steel and iron trades have shown no appreciable change during the past week. The few works carrying on meantime are doing so by the aid of continental materials. Several works producing steel sheets are very busy and are booked ahead for a considerable period, but the output of heavy steel is practically at a standstill. Steel sheets are firmer in price, and the scarcity of sections has caused a similar tendency. Few bar iron mills are working, and these are chiefly engaged producing steel bars from foreign billets. Bar iron, therefore, is scarce, and the nominal price is £12 to £12 10s. for Crown quality bars for home delivery. The pig iron furnaces remain inactive, and stocks in makers' yards have been practically wiped out. Foundry qualities are quoted 100s. per ton for No. 1, and 95s. No. 3, for delivery on the resumption of work at the furnaces.

Coal.

In view of the efforts to settle the strike and the increasing output of home coal, conditions in the coal market have changed somewhat during the past week. Neither merchants nor consumers are disposed to purchase meantime, and this is most noticeable in respect to foreign fuel. Scottish fuel is chiefly mentioned in the restricted demand. This contraction in business has caused a weakening in prices practically all round, and nominal quotations are given as follows:—Silesian, screened, 75s.; unscreened, 72s. 6d.; Westphalian, screened, 72s. 6d.; unscreened, 70s., all per ton f.o.t. Glasgow, Grangemouth, Bo'ness or Leith. American, unscreened, 72s. 6d. per ton f.o.t. Glasgow; Westphalian foundry coke, 65s. per ton f.o.t. Grangemouth or Bo'ness; German industrial brown coal briquettes, 55s. per ton f.o.t. Grangemouth, Bo'ness, or Leith; Scottish patent fuel, 65s. per ton f.o.b. Glasgow, Grangemouth or Bo'ness, and 1s. per ton more at Leith; Scottish screened coal, 65s. to 70s.; triping, 65s.; and dross, 50s., all per ton in truck at pit. English screened coal, 75s.; unscreened, 60s. to 65s., all per ton delivered Glasgow district.

Cheaper Household Fuel.

The Scottish Coalowners' Associations have agreed to recommend that, as from Monday next, November 15th, the price (maximum) for all coal (except anthracite), should be 55s. per ton at the pit on condition that the whole reduction in price is passed on to the consumer. That would make the retail price somewhere in the region of 3s. 6d. per cwt.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Outlook.

There has been great disappointment in this district that the negotiations for a settlement of the coal dispute have not so far resulted in success. Last week-end a very confident feeling prevailed that the end was really in sight, but since then most people have been compelled to modify their views, and there is a very considerable fear that the termination will not come before the end of this month or early December, when the likelihood is that many more men will return to work in order to earn some money for Christmas. Hours of work form the chief stumbling block to an agreement, and on this point the coalowners in this district are very firm indeed on their demand for an eight-hour day, and it is taken for granted that before the miners' leaders give way on the question of hours and district agreements, they will submit the matter to the rank and file, which raises another interesting point. It affects the position of the miners who have already returned to work, and whether they are to have a voice in the decisions come to. In South Wales there are now about 21,000 miners at work, and it is very doubtful whether they would be allowed to take part in any Lodge meetings called by the officials of the Miners' Federation, so that the prospects are that any resolutions come to would be those passed by miners who are opposed to the coalowners' terms. Even now grave fears are entertained that the only way out of the present position is by the drift back of the miners, which, so far as this district is concerned, is a slow business.

Export Prospects.

As time goes by it is increasingly recognised that export business in coals from South Wales this year is becoming a less workable proposition. Even if there were to be a quick settlement and an early general resumption of work, it is taken for granted that comparatively few cargoes could be shipped by the end of December. It will be very difficult if not impossible to say what coals will be available, in view of the restrictions which will be inevitable in order that home requirements may be first supplied. At the same time it is not overlooked that this is very largely an exporting centre, and it is imperative that a certain amount of coals should be freed for export, as otherwise collieries would be held up for empty wagons and would not be able to work. In these circumstances it is almost certain that collieries will be permitted to export a portion of their output almost from the very commencement of production on any material scale. How prices will rule is still a matter for conjecture, as most collieries are not naming figures until there is a settlement. A small amount of business has been done for shipment within a month or so of a general resumption. Best Admiralty large coals have been purchased from 30s. to 35s. f.o.b., and superior second qualities round about 27s. 6d., while ordinary large have been sold about 23s. 6d. Buyers are not operating ahead, or over a period to any extent, as after the first month or so it is believed that prices will fall to a lower level, which is only natural as production expands. Meantime the prices agreed upon as maximum figures for coals for all purposes, that is for newly wrought Welsh coals, are as follows:—Large coals, 55s.; through coals, 50s.; and smalls, 40s.; these being pithead prices.

Coal Imports.

Since the commencement of the stoppage the quantity of coals imported into South Wales has amounted to over a million and a-quarter tons. Last week the total was over 114,000 tons, and the quantity to be discharged during the remainder of this month and next is estimated at over a quarter of a million, the bulk of which is coming from America. There are now round about twenty-five steamers discharging their cargoes at local ports, and next month will see the arrival of two substantial cargoes of Indian coal, the first ever known to have been brought to South Wales. Comparatively little fresh business is now being arranged in foreign coals, and chartering operations are for the moment more or less suspended pending the course of the negotiations. It is, however, interesting to note that while tonnage has been taken up for November in readiness to load American coals at a rate of freight of 35s., tonnage has also been chartered with laydays running to the end of February at 17s. per ton. Thus it will be seen that American coals will be arriving in the United Kingdom as late as next March. Considering the very considerable quantity of foreign coals which are due to reach South Wales ports this month and next fears are held in some quarters that if the coal dispute here is quickly settled grave difficulties will arise over the question of wagon supply.

Craftsmen's Terms.

Representatives of the South Wales Coalowners' Association and the Enginemen, Boilermen and Craftsmen's Association met on Monday in accordance with the terms of their joint agreement to settle the percentage and subsistence wage payable for the month of November. It was agreed to continue the 42·22 per cent. and the subsistence wage of 8s. 0½d. to all workmen over twenty-one years of age, and the 8s. 6½d. to fully skilled and competent craftsmen, as hitherto paid in the coalfield, to the end of January, 1927, also the continuation of week-end payment at the pre-stoppage rate of time and a-half.

Threatened Closing of Colliery.

Great anxiety prevails in the Merthyr district regarding the threatened closing down of the Hill's Plymouth collieries. The affairs of this undertaking are in the hands of a receiver. At the end of last week a mass meeting of about 1000 miners was held to consider the position, and it was decided to make an appeal to Lord Buckland to assist in avoiding such a calamity as the closing up of the collieries, which would mean unemployment for about 1600 workmen, a loss of £5000 per week in wages, while Merthyr would lose £14,000 a year in rates. A deputation has since had an interview with Lord Buckland, when the latter explained that he had received full particulars of the proposal from the receiver, and he had been compleled to turn it down as a commercial proposition. However, the workmen's representatives urged Lord Buckland not to refuse his support until they had had an opportunity of placing the information before their district committee, when it was expected that a proposal would be formulated which would be submitted to Lord Buckland subsequently.

Tin-platers' Bonus.

The Joint Standing Committee of the Industrial Council of the Tin-plate and Welsh Sheet Trade held an adjourned meeting on Monday at Swansea, when, after a long discussion, the employers agreed to continue the payment of the 7½ per cent. *ex gratia* bonus to adult datal workmen on a base rate of 5s. 6d. a day and under, and 3¾ per cent. to the remainder of the workmen, until February, 1927. Some time ago the employers intimated their intention to discontinue this payment, which has been in operation for some years. This new agreement is conditional upon no claims of a general character being made during the extended period of the bonus.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

The Council of the Institution of Electrical Engineers, at a meeting held last week, unanimously elected Senatore G. Marconi, G.C.V.O., LL.D., D.Sc., an honorary member of the Institution.

Bruce Peebles and Co., Ltd., of Edinburgh, ask us to announce that they have appointed Messrs. Sellar and Fraser, of 144, St. Vincent-street, Glasgow, as their agents for the West and North of Scotland.

A. and J. Main and Co., Ltd., of Australia House, Strand, London, W.C. 2, and Possilpark, Glasgow, N., ask us to state that they have acquired a controlling interest in Main Ropeways, Ltd., of 47, Victoria-street, London, S.W. 1.

The British Cast Iron Research Association asks us to announce that its registered offices at 75, New-street, Birmingham, together with the laboratory at 56, Guildford-street, Birmingham, have now been removed to 24, St. Paul's-square, Birmingham, to which address it requests that all communications should be sent. Telegrams, "Cira, Birmingham;" telephone, Central 1885.

The Parsons Motor Company, Ltd., of Town Quay Works, Southampton, asks us to announce that the name of the firm has been changed to "The Parsons Oil Engine Company, Ltd." This change has been deemed desirable in order to bring the title of the firm more into line with the articles which it produces, and that it may not in future, as in the past, be confused with either electric manufacturers or the makers of motor cars. The directorate and management remain exactly the same as under the original title.

CONTRACTS.

Vickers Ltd. have received an order from Bibby Bros. and Co. to equip the motor vessels Dorsetshire and Somersetshire for service as Government transports.

Gent and Co., Ltd., of Leicester, have been instructed to install in the new Legislative Government buildings at Delhi a complete system of pulsynetic clocks, including transmitter and transmitting relays.

The Oerlikon Company has received from the Spanish Northern Railway—Compañia de los Caminos de Hierro del Norte de España—an order for twenty-two electric locomotives for heavy duty. These engines, which are to haul trailing loads of 1200 tons, will be 1500-volt direct-current engines, working with overhead collection, and will each have an output of 2040 horse-power at about 20·5 miles per hour, and a maximum speed of 56 miles per hour.

British Brown-Boveri, Ltd., has received an order for a high-speed electric locomotive in connection with the electrification of the Bombay-Igatpuri and Bombay-Poona sections of the Great Indian Peninsula Railway. The locomotive will be designed for direct current at an average contact wire pressure of 1400 volts. It will be of the 2-AAA-2 (4–6–4) type with a one-hour rating of 2450 horse-power at the motor shafts at a speed of 36 miles per hour, and will be designed for a maximum speed in service of 75 miles per hour. It will have six motors.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	18/6 to 21/-
(1) Spanish	18/6 to 21/-
(1) N. African	18/6 to 21/-
N.E. Coast—	
Native	—
Foreign (c.i.f.)	21/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	—	—
No. 1 Foundry	‡4 15 0 to 5 0 0	—
No. 3 Foundry	‡4 10 0	—
‡ *For delivery after resumption of work at furnaces.*		
N.E. Coast—		
Hematite Mixed Nos.	4 8 6	4 8 6
No. 1	4 9 0	4 9 0
Cleveland—		
No. 1	6 5 0	6 5 6
Silicious Iron	6 5 0	6 5 6
No. 3 G.M.B.	6 0 0	6 0 6
No. 4 Foundry	5 19 0	5 19 6
No. 4 Forge	5 18 6	5 19 0
Mottled	5 17 6	5 18 0
White	5 17 6	5 18 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	10 10 0	—
North Staffs. Forge	3 17 6	—
„ „ Foundry	4 7 6	—
(3) Northampton—	(*None offered.*)	
Foundry No. 3	3 5 0 to 3 10 0	
„ Forge	2 16 0 to 2 17 0	
(3) Derbyshire—	(*None offered.*)	
No. 3 Foundry	3 7 6 to 3 15 0	
Forge	3 2 9 to 3 5 0	
(3) Lincolnshire—	(*None offered.*)	
No. 3 Foundry	3 8 0	—
No. 4 Forge	3 5 6	—
Basic	3 6 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 15 6 (*a*) / 4 18 6 (*b*) / 5 2 0 (*c*)	— / — / —

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	12 0 0	11 0 0
Best	—	—
N.E. Coast—		
Common Bars	11 15 0	—
Lancs.—		
Crown Bars	12 10 0	—
Second Quality Bars	11 5 0	—
Hoops	14 0 0	—
S. Yorks.—		
Crown Bars	12 10 0	—
Best Bars	13 10 0	—
Hoops	14 10 0	—
Midlands—	(*Prices nominal.*)	
Crown Bars	11 5 0 to 11 10 0	
Marked Bars (Staffs.)	14 0 0	—
Nut and Bolt Bars	10 5 0 to 10 10 0	
Gas Tube Strip	12 10 0	—

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	—
Ship Plates, ¼in. and up	8 2 6	7 0 0
Sections	7 12 6	6 5 0
Steel Sheets, under 3/16in. to ¼in.	12 0 0 to 12 10 0	
Sheets (Gal. Cor. 24 B.G.)	— £17 5 0 to 18 5 0	

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 12 6	—
Angles	8 12 6	—
Boiler Plates	12 0 0	—
Joists	8 0 0	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 2 6	—
Soft Billets	7 5 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 0 0†	—
Light Rails	8 5 0 to 8 10 0	
Billets	8 0 0 to 11 10 0†	
Manchester—		
Bars (Round)	9 10 0	—
„ (Small Round)	10 0 0	—
Hoops (Baling)	11 0 0	11 0 0
„ (Soft Steel)	10 15 0	10 15 0
Plates	8 7 6 to 8 15 0	
„ (Lancs. Boiler)	11 10 0 to 12 0 0	
Sheffield—		
Siemens Acid Billets	11 0 0	—
Bessemer Billets	11 0 0	—
Hard Basic	9 2 6	—
Intermediate Basic	8 12 6	—
Soft Basic	7 15 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 10 0	—
Midlands—		
Small Rolled Bars	8 15 0 to 9 5 0	
Billets and Sheet Bars	—	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	17 10 0 to 17 15 0	
Angles	8 12 6 to 8 17 6	
Joists	8 12 6 to 8 17 6	
Tees	9 12 6 to 10 17 6	
Bridge and Tank Plates	—	
Boiler Plates	—	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	24/6 to 25/6
Block Tin (cash)	309 15 0
„ (three months)	297 15 0
Copper (cash)	57 12 6
„ (three months)	58 10 0
Spanish Lead (cash)	29 6 3
„ (three months)	29 11 3
Spelter (cash)	33 3 9
„ (three months)	33 6 3
Manchester—	
Copper, Best Selected Ingots	65 7 6
„ Electrolytic	66 10 0
„ Strong Sheets	92 0 0
„ Tubes (Basis Price) lb.	0 1 1
Brass Tubes (Basis Price) lb.	0 1 0
„ Condenser lb.	0 1 2½
Lead, English	31 0 0
„ Foreign	29 17 6
Spelter	33 10 0

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/9 to 1/10 per lb.	
Ferro Tungsten	1/5 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/6
„ „ 6 p.c. to 8 p.c. „	£22 0 0	7/3
„ „ 8 p.c. to 10 p.c. „	£20 15 0	6/6
„ „ Specially Refined		
„ „Max. 2 p.c. carbon	£37 0 0	12/6
„ „ „ 1 p.c. „	£43 5 0	15/-
„ „ „ 0·70 p.c. carbon	£54 0 0	17/6
„ „ „ carbon free	1/5d. per lb.	
Metallic Chromium	3/- per lb.	
Ferro Manganese (per ton)	£15 for home, £15 for export	
„ Silicon, 45 p.c. to 50 p.c.	£10 17 6 scale 5/- per unit	
„ „ 75 p.c.	£16 5 6 scale 6/- per unit	
„ Vanadium	14/9 per lb.	
„ Molybdenum	5/3 per lb.	
„ Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	10/- per lb.	
Aluminium (per ton)	£112	

FUELS.

SCOTLAND.

	(*Prices nominal.*)	Export.
Lanarkshire—		
(f.o.b. Glasgow)—Steam		15/9
„ „ Ell		16/6
„ „ Splint		16/6 to 17/-
„ „ Trebles		15/9
„ „ Doubles		14/- to 14/6
„ „ Singles		13/9
Ayrshire—		
(f.o.b. Ports)—Steam		16/9
„ „ Jewel		17/- to 17/6
„ „ Trebles		17/-
Fifeshire—		
(f.o.b. Methil or Burntisland)—Steam		12/6 to 14/9
Screened Navigation		21/-
Trebles		14/- to 15/-
Doubles		14/-
Singles		13/- to 13/6
Lothians—		
(f.o.b. Leith)—Best Steam		14/- to 14/3
Secondary Steam		13/6
Trebles		14/6 to 14/9
Doubles		13/6
Singles		13/6

ENGLAND.

	Inland. (*Nominal; none on offer.*)	Export.
(8) N.W. Coast—		
Steams		*No quotation.*
Household		„ „
Coke		„ „
Northumberland—		
Best Steams		16/-
Second Steams		14/6 to 15/-
Steam Smalls		8/- to 8/6
Unscreened		13/- to 13/6
Household		20/- to 22/-
Durham—		
Best Gas		18/6 to 19/-
Second		15/- to 15/6
Household		20/- to 22/-
Foundry Coke		18/- to 20/-
Sheffield—		
Best Hand-picked Branch	31/- to 34/-	—
Barnsley Best Silkstone	28/- to 30/-	—
Derbyshire Best Brights	26/- to 28/-	—
„ „ House	24/- to 25/-	—
„ „ Large Nuts	17/- to 20/-	—
„ „ Small	12/6 to 14/-	—
Yorkshire Hards	17/- to 19/6	—
Derbyshire Hards	16/- to 19/-	-
Rough Slacks	10/- to 12/6	—
Nutty Slacks	7/6 to 9/-	—
Smalls	3/6 to 6/-	—
Blast-furnace Coke (Inland)*	—	—
„ „ (Export) f.o.b.		16/- to 17/-

(9) SOUTH WALES.

	(*All prices nominal.*)
Cardiff—	
Steam Coals :	
Best Smokeless Large	26/- to 27/-
Second „ „	24/6 to 25/6
Best Dry Large	24/- to 25/-
Ordinary Dry Large	21/- to 22/-
Best Black Vein Large	25/6 to 26/-
Western Valley Large	24/6 to 25/-
Best Eastern Valley Large	24/- to 25/-
Ordinary „ „	23/6 to 24/-
Best Steam Smalls	17/- to 18/-
Ordinary „	16/- to 17/-
Washed Nuts	19/- to 20/-
No. 3 Rhondda Large	26/6 to 27/-
„ „ Smalls	18/- to 18/6
No. 2 „ Large	24/- to 25/-
„ „ Through	20/- to 21/-
„ „ Smalls	15/- to 16/-
Foundry Coke (export)	40/- to 50/-
Furnace Coke (export)	25/- to 30/-
Patent Fuel	42/6 to 45/-
Pitwood (ex ship)	35/- to 37/6
Swansea—	
Anthracite Coals :	
Best Big Vein Large	39/- to 40/-
Seconds	32/6 to 35/-
Red Vein	27/- to 29/-
Machine-made Cobbles	47/6 to 50/-
Nuts	47/6 to 50/-
Beans	42/6 to 44/-
Peas	23/- to 25/-
Breaker Duff	7/6 to 8/-
Rubbly Culm	12/6 to 13/6
Steam Coals :	
Large	22/6 to 24/6
Seconds	20/- to 22/-
Smalls	11/- to 15/-
Cargo Through	16/6 to 17/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayreshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. * For blast-furnaces only, 17/-, with fluctuations according to analysis; open market 17/6 to 19/- at ovens. † Latest quotations available. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham.

French Engineering Notes.

(*From our Correspondent in Paris.*)

The Situation.

UNDER present conditions it is impossible to say what is likely to be the situation of the engineering trades in the early future. The improvement of the franc may be justified, and everyone believes that in view of the country's potential wealth it is still far below its real value; but there are, nevertheless, so many unsuspected possibilities arising from the financial problems now awaiting solution that the prevailing optimism is tinged with some apprehension. It is not even certain that a stabilisation can be effected except on a gold basis, which means bringing the franc back to par, and that is, of course, out of the question. Without a gold basis there will always necessarily be a fluctuation in currency values. A serious feature is that, while the franc is improving, there is a continuous advance in prices all round. Although prices are still below the international level, they are nevertheless approaching it, and there is a risk that if the margin between the two should further widen it will place this country at the mercy of foreign competition. For the moment there is no such danger, and most manufacturers are still relying upon an export trade, although they are aware that such trade is precarious and that they must look more particularly to the home market in the future. Here again business is restricted by the continuous decline in the country's purchasing power and by the holding up of all public works. Because of the financial situation there is nothing to give promise of an early activity, and manufacturers generally are looking forward to a period of restricted buying and even of depression, the duration of which it is impossible to foresee.

Miners' Wages.

In view of the higher prices of coal the miners in the northern coalfields are asking for an advance in wages, a demand which is naturally rejected on the ground that the present prosperity is purely artificial and will certainly be arrested as soon as the strike in Great Britain comes to an end. The coalowners know very well that the end of the strike will see an intensified competition of British fuel, for if the cost of coal at the pithead in Great Britain should be reduced sufficiently the French companies would experience some difficulty in making a profit at all. A settlement of the dispute on a basis which would enable British coalowners to export coal at a competitive price would permit of their recovering some of the foreign markets. During the past six months great efforts have been made to get sufficient supplies from the Saar and the Ruhr to replace British coal entirely, but the quantities imported are still so far below requirements that serious inconvenience is being caused in some parts of the country, particularly on the Atlantic seaboard. In Belgium, also, the supplies of coal are insufficient, and the miners are being asked to work more than eight hours a day as a temporary expedient to enable the country to tide over a difficult period; but the men's unions are objecting so strongly to the idea of putting in more than eight hours a day in the pits that it is doubtful whether the proposal will be carried into effect.

Commercial Vehicles.

The show of commercial vehicles which followed upon the automobile exhibition in Paris did not indicate any changes in the general trend of the heavy branch of the motor car industry. Notwithstanding the large number of motor lorries in service, there are few makers who lay themselves out specially for the construction of commercial vehicles, and the business is still largely in the hands of motor car firms which turn out mainly touring cars. That fact may be attributed partly to the unsatisfactory condition of things caused by the throwing on the market, after the Armistice, of many thousands of American lorries, and the business since then seems to have consisted largely in putting those vehicles in running order for contractors and others who are induced to purchase them by the low prices at which they are offered. Until this large number of American lorries has been entirely absorbed there can be little hope of activity in the commercial branch of the industry. The vehicles exhibited at the show were mainly built for passenger traffic, and some of them had remarkably luxurious and spacious bodies, one in particular being the huge six-wheel Renault vehicle built for the Compagnie Transatlantique, which is using cars of this type for the transport of tourists in the Sahara desert. The only other novel departure in the heavy vehicle industry is the equipping of lorries with suction gas plants. It cannot be said that the use of suction gas is making so much headway as would seem to be justified by its claims on the score of economy, but every lorry and tractor builder believes that the future lies in the suction gas vehicle, and each is endeavouring to work out the problem on his own particular lines.

Barrage Reservoirs.

The Paris Municipal Council has decided in principle to participate in the construction of three barrage reservoirs in the upper valley of the Seine, and the urgency of the work is insisted upon in a report just presented by a commission which recommends that the reservoirs should be created at La Cure, at Pennestière, near Château-Chinon, and at Champaubert-aux-Bois, near Vitry le-François. They will have a total capacity of 140 million cubic metres. The object of the reservoirs is to regulate the level of the Seine and minimise the risk of floods, and at the same time to supply Paris with water, while it is further claimed that hydro-electric installations can be laid down which will provide 20 million kilowatts of energy. While the scheme is approved of by the municipal engineers, it is meeting with some criticism elsewhere, and it will probably be a long time before the construction of the reservoirs is authorised. Moreover, in the present financial situation it is impossible to put in hand any undertaking which will involve such a huge expenditure as will be necessary for the barrages, and their construction will probably depend upon the success or otherwise of the negotiations for bringing water to Paris from the Vals de Loire.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

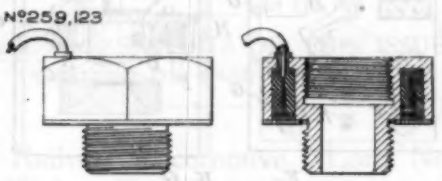
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

259,123. March 29th, 1926.—STARTING DEVICES, H. E. Jodor, Boulevard Sakakini 49, Marseilles, France.

This device is intended to overcome the difficulty of starting petrol engines when they have become cold, and takes the form of an adaptor into which the sparking plug is screwed and which

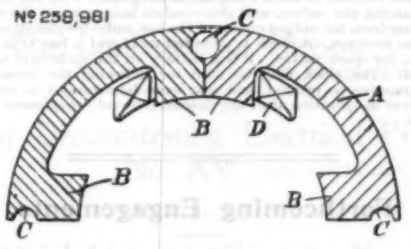


itself is screwed into the normal sparking plug hole. This adaptor is provided with an electrical heating element that warms up the surroundings sufficiently to ensure the first few explosions, after which it is cut out of action.—*October 7th*, 1926.

DYNAMOS AND MOTORS.

258,981. July 25th, 1925.—IMPROVEMENTS IN OR RELATING TO DYNAMO-ELECTRIC MACHINES, The British Lighting and Ignition Company, Ltd., of B.L.I.C. Works, Chestonroad, Aston, Warwickshire, and James Cochrane Hutton, of "Canvey," Penn's-lane, Erdington, Birmingham.

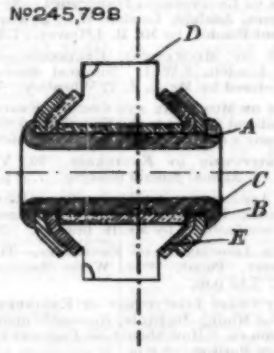
The main object of this invention is to cheapen and improve the stator construction of dynamo-electric machines. The illustration represents a four-pole stator structure. Each section extends over a quarter of the entire circumference and comprises a yoke A of arcuate shape formed at each end with a half pole



core B, shaped so as to make contact with the half pole cores of adjacent sections to which they are welded, the junction being preferably, as indicated, on the centre line of each complete pole. Semi-circular grooves C may be formed in the surfaces to be joined so as, after welding, to constitute passages through which bolts for securing the end covers of the machine may be passed. The exciting coils D are placed over the completed pole cores after assembly and are retained in position in any suitable manner. A modified form of construction is also described.—*October 7th*, 1926.

245,798. January 11th, 1926.—COMMUTATORS, Deutsche Gasglühlicht-auer-Gesellschaft m.b.H., 11, Ehrenbergstrasse, Berlin, Germany.

It would seem that this invention, as disclosed by the illustrations in the specification, is impossible of realisation unless the

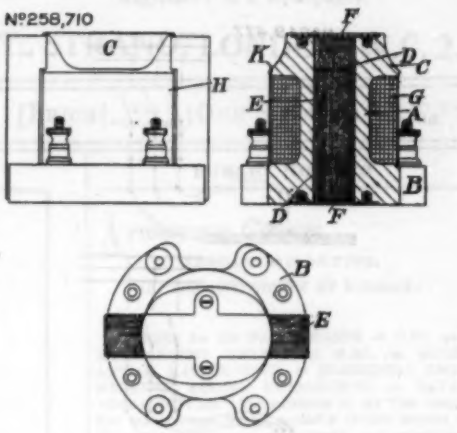


phrase "hollow rivet," applied to the appliance shown at A refers to some new method of passing a flange B through a hole C of smaller diameter. Otherwise, the commutator is comparatively normal, having segments D, insulation E, and binding discs F.—*October 7th*, 1926.

TELEGRAPHS AND TELEPHONES.

258,710. July 28th, 1925.—IMPROVEMENTS IN TRANSFORMERS, Lissen Ltd., and Richard Percy Richardson, all of Lissenium Works, Friars-lane, Richmond, Surrey.

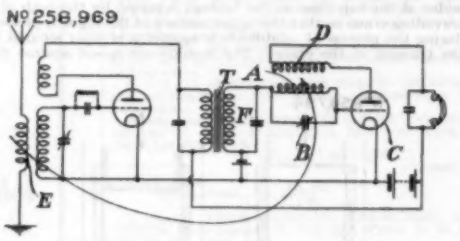
This invention relates to small iron-cored transformers, more particularly such as are used in radio communication for the interconnection of thermionic valves, and is applicable also to auto-transformers or choking coils. The bobbin is moulded of ebonite and comprises a cylindrical part A and flanges B and C. In each flange there is a slot D a little greater in depth than the depth of the iron core E and equal in width to the thickness of the core. The core is built up of alternate U and T-shaped laminations, the stems of the T's being inserted, one half from one end and one half from the other end into the bore of the bobbin, while the tops of the T's and the bottoms of the U's lie side by side in the slots D. The laminations are held in place by brass or other plates F, which may be extended and bent around to shield the outer limbs of the transformer. The winding or windings G on the bobbin A may be enclosed by a sheet



of metal, celluloid, fibre or other insulating material H, which wraps about the fillets K formed on the inner faces of the flanges. The ends of the winding or windings are carried through the base and along slots in its under surface to terminals.—*September 30th*, 1926.

258,969. July 9th, 1925.—IMPROVEMENTS IN OR RELATING TO RADIO RECEIVING APPARATUS COMPRISING MEANS FOR REJECTING UNDESIRED SIGNALS, Igranic Electric Company, Ltd., of 147, Queen Victoria-street, London, E.C. 4, and Peter William Willans, of "The Cottage," Pattishall, Towcester.

This invention relates to radio receiving apparatus of the kind in which means are provided for rejecting undesired signals. The circuit tuned to the undesired or interfering frequency—consisting of an inductance A in parallel with a variable condenser B—is connected, as shown, between one end of the secondary of the intervalve transformer T and the grid of the low-frequency valve C. In the plate circuit of the low-frequency

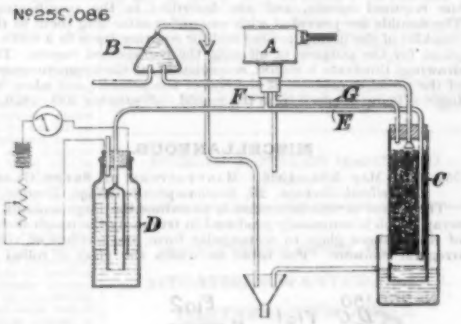


valve there is a reaction coil D, and this reaction coil is coupled to the inductance A, whereby in accordance with well-known principles the resistance of the tuned circuit A B is reduced to a very low value. The inductance coil A is also coupled to the aerial tuning inductance E, whereby a large impedance is thrown into the aerial circuit for signals of an undesired frequency. The secondary of the intervalve transformer T, preferably has a condenser F connected in parallel with it, so that the high-frequency current from the filament of the valve C will be permitted to reach the end of the tuned circuit remote from the grid of the low-frequency valve C, and thereby enhance the desired effect upon the signals of undesired frequency.—*October 7th*, 1926.

MEASURING AND TESTING INSTRUMENTS.

259,086. January 27th, 1926.—MEASURING THE AMOUNT OF GAS DISSOLVED IN A LIQUID, H. A. Daynes and the Cambridge Instrument Company, Chesterton-road, Cambridge.

This apparatus is primarily intended for determining the amount of oxygen in boiler feed water, and depends for its indications on the difference in heat conductivity of two gases, which difference is shown by the device A or cathorometer—the subject of a separate patent specification. The water to be



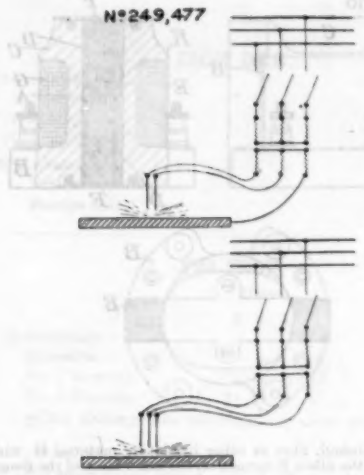
tested is supplied to a device B which maintains a constant head and goes on to the scrubbing "tower" C, filled with small pieces of nickel. Hydrogen is generated in the electrolytic cell D, and passes to the bottom of the tower by way of the pipe E. There is a branch which leads to the cathorometer A at F, and the gases which result from the reaction of the hydrogen and the water are also taken there by the pipe G for comparison.—*October 7th*, 1926.

WELDING.

249,477. January 14th, 1926.—ELECTRIC ARC-WELDING ARRANGEMENTS FOR THREE-PHASE CURRENT, Hendrik Abraham Wijnand Klinkhamer, of 77, Borneschestraat, Hengelo, Overijsel, The Netherlands.

Various advantages are claimed for the system of arc welding described in this specification. As will be gathered from the diagrams, three-phase current is used and the work forms one of

the electrodes. A small constant distance is maintained between two of the electrodes, and an arc persists between them independently of variations in their distance from the work. In the lower diagram there are three electrodes arranged a short distance apart, and the work is connected to the neutral point of the

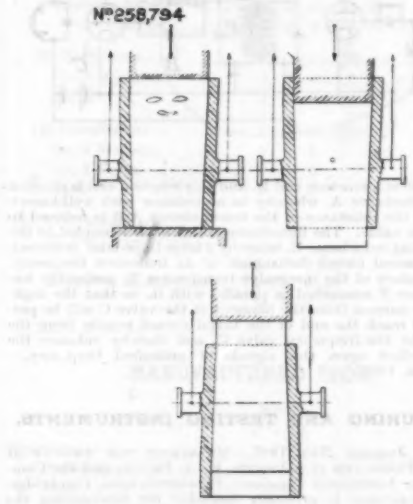


transformer. An ordinary three-phase transformer with increased magnetic leakage is employed. It is claimed to be possible to obtain a power factor of ·8 to ·9 without the short-circuit current exceeding the permissible limits.—*September 30th*, 1926.

METALLURGY.

258,794. March 19th, 1926.—Casting Steel Ingots, Meboe, Ltd., Queen Anne's Chambers, Tothill-street, Westminster.

In order to obtain steel ingots free from piping, it has been found effective to cast them in conical moulds in which the metal during the process of solidification is exposed to pressure on all sides and is forced towards the narrow end of the mould. In such a process, according to this invention, the mould which is wider at the top than at the bottom is raised by the crab of a travelling crane so that the upper surface of the ingot is pressed during the process of solidification against a plunger secured to the framing of the crane. The moulds are raised against the

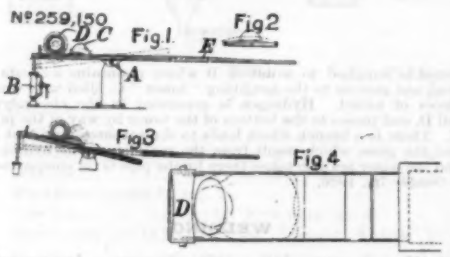


fixed plungers by rods provided with shackles and adapted to be raised and lowered at a comparatively high speed until contact is made with the plungers when the speed is reduced. Separate electric motors are connected to suitable gearing for obtaining the required speeds, and are described in the specification. The moulds are provided with means for attaching them to the shackles of the lifting devices and for rotating them in a vertical plane for the purpose of ejecting the compressed ingots. The drawings illustrate a mould, respectively, at the commencement of the pressing process, at the end of the process, and when the ingot is being released from the mould.—*September 30th*, 1926.

MISCELLANEOUS.

259,150. May 31st, 1926.—Manufacture of Sheet Glass, *L. Mellersh-Jackson*, 28, *Southampton-buildings, London*.

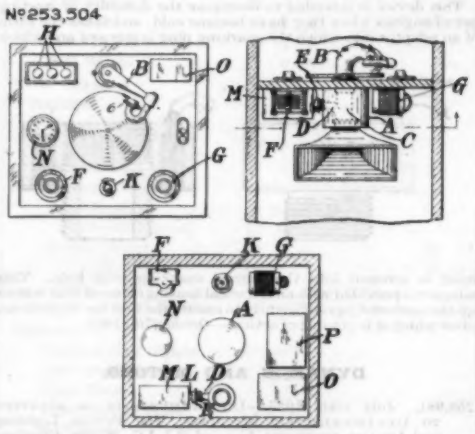
The object of this invention is to reduce the large amount of scrap which is commonly produced in trimming the rough sheets of rolled sheet glass to rectangular form, on account of their irregular contour. The table on which the glass is rolled is



mounted on a pivot A—Fig. 1—and its inclination to the horizontal can be controlled by the ram B. Its top surface is convex, as shown in Fig. 2, and on it there is dumped the mass of glass C. The roll D—see Fig. 4—is concave and presses out the glass as shown by the dotted lines, while the forward movement of the glass is assisted by tilting the table as indicated in Fig. 3. When the glass has been fully rolled out the table is returned to the horizontal and the sheet is pushed forward towards a lehr over another table E, on which it gradually assumes a flat form.—*October 7th*, 1926.

253,504. May 21st, 1926.—Improvements in or relating to Phonographs and the like and Radio Receivers, *Marconi's Wireless Telegraph Company, Ltd., of Marconi House, Strand, London, W.C. 2.*

In the construction of the combined phonograph and wireless receiver described in this specification, the radio and phonograph apparatus are as far as possible mounted on the same panel, and an endeavour is made to use common elements for the two devices. Moreover, the construction is such that the radio receiving elements are applied with as few changes as possible to the existing phonograph structure. The supporting shelf or panel provided for the phonograph spring motor and turntable are used for mounting the radio apparatus. In the drawings, A is the operating motor of the phonograph and B the tone arm. The only actual change necessary in the usual arrangement is the substitution of a modified sound conduit C for that usually



provided in phonographs. An extension D communicates with a loud-speaker operating mechanism, so that the horn may act for both the phonograph and the radio receiver. The radio receiver comprises a variable condenser F, a tuning coil G and valves H. A filament resistance is shown at K, and the loud-speaker operating mechanism E is attached to the output circuit of the receiver. This loud-speaker connection is represented by a small conduit L, connecting the loud speaker with the box M containing the valves, and this conduit may contain the wires leading from the output circuit of the last audio frequency valves in the receiver. A clock is mounted at N and a box O is provided for spare valves. P is a battery on the underside of the panel. The clock may be used for following the broadcast programmes as printed, and may even be arranged to set the receiver in operation after any desired interval.—*September 30th*, 1926.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Institute of Metals: Sheffield Local Section.—Applied Science Department of the University, St. George's-square, Sheffield. "Ingots and Ingot Making," by Mr. H. Brearley. 7.30 p.m.

Institute of Metals: Swansea Local Section.—Metallurgical Department, University College, Singleton Park, Swansea. "Zinc Smelting and Recovery of its By-products," by Mr. J. H. Wells. 7.15 p.m.

Institution of Engineering Inspection.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Further Notes on Ciment Fondu," by Mr. H. J. Davey. 7.30 p.m.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Informal discussion, "Estimating," introduced by Mr. L. J. T. Wheatley. 7 p.m.

Institution of Municipal and County Engineers.—Visit of the West Midland District to the Enderby and Stoney Stanton Granite Company's quarries at Enderby, Leicester. 2 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Annual general meeting. 7.30 p.m.

Keighley Association of Engineers.—Room 14, Temperance Institute, Keighley. Lecture, "Modern Production Methods—Turret Lathes," by Mr. H. Bradley. 7.30 p.m.

Manchester Association of Engineers.—The Engineers' Club, Manchester. Paper, "Steel Works Machinery," by Mr. James Smith. 7.15 p.m.

North-East Coast Institution of Engineers and Shipbuilders.—The Mining Institute, Newcastle-upon-Tyne. Resumed discussion on "How Should an Engineer be Trained?" by Sir Theodore Morison. 6 p.m.

Popular Talk in Aid of King Edward's Hospital Fund for London.—Fyvie Hall, Polytechnic, Regent-street, London, W. 1. "Liquid Air," by Mr. W. E. Garner. 5 p.m.

Railway Club.—25, Tothill-street, Westminster, London, S.W. 1. Paper, "Light Signalling," by Mr. W. J. Thorrowgood. 7.30 p.m.

SATURDAY, NOVEMBER 13TH.

Institution of Civil Engineers: Birmingham and District Association.—Visit to South Staffordshire Waterworks at Lichfield and Dudley. 11 a.m.

MONDAY, NOVEMBER 15TH.

Bradford Engineering Society.—The Technical College, Great Horton-road, Bradford. Exhibition of film lent by C. A. Parsons and Co., Ltd., showing 50,000-kilowatt Parsons steam turbo-alternator at Chicago. 7.30 p.m.

Institution of Automobile Engineers: Scottish Centre.—Royal Technical College, Glasgow. Paper, "Recent Researches on Friction and Lubrication," by Mr. J. E. Southcombe. 7.30 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Howard Lecture, "Recent Experiments on the Properties of Steam at High Pressure," by Professor H. L. Callendar. 8 p.m.

TUESDAY, NOVEMBER 16TH.

Institute of British Foundrymen: Lancashire Branch, Burnley Section.—Municipal College, Ormerod-road, Burnley. Lecture, "A Talk about the Cupola," by Mr. F. Perkins. 7.15 p.m.

Institution of Automobile Engineers: Wolverhampton Centre.—Engineering and Scientific Club, Queen-street, Wolverhampton. Paper, "The Effect of Reduced Intake-air Pressure and of Hydrogen on the Performance of a Slow-speed Solid-injection Engine," by Mr. G. F. Mucklow. 7.30 p.m.

Institution of Civil Engineers.—Great George-street, London, S.W. 1. Paper, "H.M. Dockyard, Rosyth," by Messrs. T. B. Hunter and A. L. Bell. 6 p.m.

Institution of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow. Paper, "Diesel Engines," by Mr. D. M. Shannon. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. "The Acoustics of Public Buildings," by Dr. G. W. C. Kaye. 5.15 p.m.

TUESDAY AND WEDNESDAY, NOVEMBER 16TH AND 17TH.

Society of Glass Technology.—Sheffield. Celebration of tenth anniversary.

WEDNESDAY, NOVEMBER 17TH.

Institution of Automobile Engineers.—Connaught Rooms, Great Queen-street, London, W.C. 2. Annual dinner. 7.15 for 7.30 p.m.

Institution of Automobile Engineers.—Chamber of Commerce, New-street, Birmingham. Joint meeting of Coventry and Birmingham graduates. Debate, "That the Supersession of the Motor Cycle Combination by the Small Car is Imminent." 7.30 p.m.

Institution of Civil Engineers.—Great George-street, London, S.W. 1. Students' meeting. Address by Mr. J. E. W. Monkhouse. 6.30 p.m.

Institution of Electrical Engineers: South Midland Centre.—The University, Edmund-street, Birmingham. Wireless Section meeting. Address by Professor C. L. Fortescue. 7 p.m.

Liverpool Engineering Society.—The Temple, Dale-street, Liverpool. Paper, "Longitudinal Strength of Ships," by Dr. A. M. Robb. 6 p.m.

Royal Meteorological Society.—49, Cromwell-road, South Kensington, London, S.W. 7. Papers: "The Nile Flood and World Weather," *Memoirs*, Vol. I, No. 5, published October, 1926, by Mr. E. W. Bliss; "The Period of Simple Vertical Oscillations in the Atmosphere," and "An Investigation of Periodicities in Rainfall, Pressure and Temperature at Certain European Stations," by Mr. D. Brunt. 5 p.m.

Society of Technical Engineers: Manchester Area.—Milton Hall, Deansgate, Manchester. Address on "Impressions of Industrial Conditions in U.S.A.," by Mr. S. Ratcliffe. 8 p.m.

Society of Technical Engineers.—102, Belgrave-road, London, S.W. 1. Address, "The New Laws relating to Industrial Organisation in Italy," by Commendotore Luigi Villari. 7.30 p.m.

THURSDAY, NOVEMBER 18TH.

Institution of Automobile Engineers.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Paper, "Worm Gears," by Mr. S. Miall. 7.30 p.m.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Lecture, "The Applications of Electricity to Agriculture," by Dr. A. Ekstrom. Exhibition of film entitled "American Agriculture and Farmhouse Electrification," by Mr. J. W. Beauchamp. 6 p.m.

Royal Aeronautical Society.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "Methods of Performance Testing and Analysis," by Mr. R. S. Capon. 6.30 p.m.

FRIDAY, NOVEMBER 19TH.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Paper, "Electric Locomotives: A Method of Classifying, Analysing, and Comparing their Characteristics," by Mr. T. A. F. Stone. 6 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Lecturette, "Short Wave Wireless Communication," by Mr. B. J. Axten. 7.30 p.m.

West Bromwich Engineering Society.—Technical School, West Bromwich. Paper, "Steel Making and Special Steels," by Mr. F. A. Hurst. 7.30 p.m.

SATURDAY, NOVEMBER 20TH.

Institute of British Foundrymen: Lancashire Branch, Junior Section.—College of Technology, Manchester. Lecture, "The Foundry Cupola," by Mr. A. H. Goodger. 7 p.m.

MONDAY, NOVEMBER 22ND.

Institution of Mechanical Engineers.—Storey's-gate, Westminster, London, S.W. 1. Graduates' Section meeting. Lecture, "Archæological Engineering," by Lieut.-Colonel E. Kitson Clark. 7 p.m.

TUESDAY, NOVEMBER 23RD.

Institution of Automobile Engineers.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Informal meeting. Discussion on "Inventions relating to the Automobile." 7 p.m.

WEDNESDAY, NOVEMBER 24TH.

Institution of Automobile Engineers: North of England Centre.—The Engineers' Club, Albert-square, Manchester. Paper, "Recent Researches on Friction and Lubrication," by Mr. J. E. Southcombe. 7 p.m.

THURSDAY, NOVEMBER 25TH.

Institution of Automobile Engineers.—Training School of Vauxhall Motors, Ltd., Luton. Luton Graduates' meeting. Paper, "Lubrication," by Mr. T. T. Brown. 7.30 p.m.

FRIDAY, NOVEMBER 26TH.

Diesel Engine Users' Association.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Modern Air Compressor Practice in Oil Engine Installations," by Mr. R. L. Quertier. 3.30 p.m.

Institution of Electrical Engineers: South Midland Centre.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Paper, "Petrol and its Substitutes for Use in Internal Combustion Engines," by Colonel the Master of Sempill. 7.30 p.m.

Tunnellers' Old Comrades Association.—Gatti's Restaurant. Strand, London, W.C. 2. Annual dinner. 7 for 7.30 p.m.